COURSE

OF

MILITARY INSTRUCTION,

&c.

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COURSE

OF

MILITARY INSTRUCTION,

ORIGINALLY

COMPOSED FOR THE USE

OF THE

Royal Engineer Department.

BY

C. W. PASLEY,

LIEUT.-COLONEL ROYAL ENGINEERS, F.R.S.

AND

DIRECTOR OF AN ESTABLISHMENT FOR INSTRUCTING THE CORPS
OF ROYAL SAPPERS AND MINERS IN MILITARY
FIELD WORKS.

VOLUME II.

Containing Elementary Fortification.

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PREFACE

TO

VOLUMES II. & III.

THE volumes, now offered to the Public, lay down the Principles of Fortification, and explain the nature of Military Works, in a manner strictly elementary.* No term is any where used, which has not been previously defined, and no complex work is treated of, until all its various component parts have been thoroughly illustrated in detail. The perplexing mode, hitherto generally used in this country, of giving the dimensions of works of Fortification in foreign measures, has been rejected; and not only have our own measures invariably been used, but English phrases have also been adopted, as far as was practicable. Those technical terms, used by foreign Engineers, which it was impossible to reconcile to the idiom of our language, have been set aside, and appropriate English expressions substituted in their place; excepting only in the case of words, which by long habit have become familiar to us, and which it might, therefore, have appeared more pedantic to reject than to retain. It will also be observed, that every point, line, and angle, which can appear in a plan or section, and every part, however

* As many readers may wish to provide themselves with this Course of Elementary Fortification, who have no occasion for the Practical Geometry, I have, for their information, stated several things in the Preface to the present Volumes, which were either said or implied in VOL. I.

minute, of any work of Fortification, has its own precise name assigned to it; in entering into which details, I had in view an object, which has long appeared to me to be desirable, namely, the establishment of a fixed Nomenclature, by means of which the British Engineer or Military Officer may make his report upon a fortified place, without being under the necessity of using an uncouth and barbarous phraseology, half foreign half English.

But the characteristic, that probably will be allowed peculiarly to distinguish this work, is the perspicuity, which has been attempted throughout. To former authors on Fortification, in general, the remark, made by Plutarch upon the writings of Aristotle, may be justly applied; namely, that they can only serve to add to the knowledge or to refresh the memories of those, who have already studied under a proper master; whereas, by having the present work before him, any person of clear understanding, who has no previous knowledge of Fortification whatever, may be able to teach himself.

The very simple and perspicuous mode, in which the subject has been treated, was originally adopted by me, with a view to the instruction of the Non-Commissioned Officers and Soldiers of the Royal Engineer Department, for whose special use, the whole of the former volume of this work, and a considerable portion even of the present volume, were expressly written.* But, although such was the sole object with which I commenced, I afterwards judged it expedient to publish the Course, in order to perpetuate, if possible, a system, which was soon found to be of the most essential benefit to that peculiar branch of the service, for which it was originally composed;† and having made this decision, I enlarged the work to a much greater extent, than was absolutely necessary for the above-mentioned purpose, in order to render it

* See note (A) at the end of the Preface.
† See note (B).

more complete, and more generally useful. To the British Officer of Infantry, whose duty frequently requires him to assist in the construction of military works, who is always an essential agent in the attack and defence of fortified places and positions, and who, if he rises to command, may often have to decide upon projects laid before him by the Engineers, this book may be particularly advantageous; as it will enable him to act, on such occasions, with greater knowledge, and consequently with greater confidence and efficiency. Even to the Private Gentleman, who, from a desire of information, aims merely at a general knowledge of modern history, it may not be unacceptable; as it will afford him the means of attaining a distinct notion of military operations, in the narration of which, terms of Fortification must necessarily be introduced: nor are these terms by any means more difficult to be understood, than those of Architecture, with which every person of tolerable education is familiarly acquainted.*

Officers of the Corps of Royal Engineers, and others, who have been educated at the Military Academy at Woolwich, or at either of the Military Colleges more recently established, will of course find much in the present work, which to them will be entirely superfluous, it having been written, as was before stated, with a view to the instruction of persons, who had no previous knowledge of the subject. Yet I may venture to assert, that even the well informed Officer will meet with many useful rules and observations, which have either been entirely overlooked, or negligently slurred over, or treated in an obscure and perplexed manner, by former authors of established reputation; and some useful military

* For example, the terms, bastion, curtain, and ravelin, without which even the Gazette account of a siege cannot be properly understood, are by no means more difficult, than the architectural terms, pedestal, shaft, and capital; and yet there is scarcely any person so ignorant, as not to know the precise meaning of the three last-mentioned words.

works are herein described, no account of which is to be found in any other book.

It will be observed, that I have deviated from (what appears to me) the very ill-judged mode, hitherto followed by several elementary writers on this art, who, after laying down the construction of five or six different systems of Fortification, give their own opinions upon the advantages and disadvantages of each; and so conclude, without explaining any one system in detail, and without entering sufficiently into those fundamental rules, which apply to works of Fortification in general. Being of opinion, for reasons more fully stated in the body of the book, that this attempt at too great a multiplicity of information, tends rather to perplex than to improve a learner, I have, as a specimen of the nature of a finished fortress, given the construction of one particular system only; choosing, by way of example, that which is usually styled the first system of Vauban,* not as being the best, but as being the simplest, and therefore the most convenient for an Elementary Work. The plan, thus adopted, of course precluded me from attempting to give any new ideas of my own, as to the most suitable form for the outlines of a fortress, so that whatever value this work may be allowed to possess, must rest more upon the plea of utility than of originality. There is, however, one very important part of the subject, which will be found to be treated in a manner perfectly new. I allude to those chapters, which take into consideration the proper strength of revetments, or retaining walls, an investigation useful and interesting not only to the

* I make use of the expression "styled," because, although it passes by the name of Vauban, who used it in the construction and repairs of a great number of fortresses, he has in reality copied the construction of it so very closely from the works of former Engineers, that as far as this system is concerned, he has no just claim to the merit of invention. In his second and third systems, which are briefly noticed, but not explained in detail in the course of the following work, he is more original.

military, but also to the civil Engineer, and indeed to the learned world in general, as it has, for more than a century, engaged the attention of eminent mathematicians.

It was my design, when I first decided upon publishing the present work, to have added the rules usually followed in the regular attack of fortified places, and to have illustrated them not only by general and detailed plans and sections of the various works of a siege; but also by practical details, stating the quantity of materials, the number and best arrangement of the men, and the time requisite, for each particular operation. At the period alluded to, a work of this kind would have been highly useful to the Officers of the Corps of Royal Engineers; for those, who were desirous of acquiring the necessary information, had then no means of preparing themselves for their arduous and important duties in the field, excepting by mere theory; and it may be observed of the foreign books, to which they were obliged to have recourse, that errors are to be found in the best of them, as far as regards the practical part of Engineering, and in none of them are the whole of the field duties explained in sufficient detail. These disadvantages, however, no longer affect the Officers of the Corps of Royal Engineers, in consequence of the great improvement, which was introduced into that branch of his Majesty's service, in the year 1812, under the administration of the Earl of Mulgrave as Master-General of the Ordnance, about a year after Lieutenant-General Mann had been nominated to the command of the Corps. Since that period, the Junior Officers of the Royal Engineers, and all the Non-commissioned Officers and Soldiers of the Department, in addition to the studies requisite for their respective stations, have been diligently exercised, not only in the execution of parallels, approaches, batteries, saps, mines, and other works of a siege; but also in the manœuvres of pontoons, and in the formation of military bridges in general:* so that there is now no operation, which the British

* See note (C).

Engineer Department can be called upon to perform, in the face of an enemy, for which the officers and men may not, with propriety, be said to have been previously qualified by actual experience;* and the kind of experience, which is thus acquired at home, is peculiarly necessary for a Corps, whose duties are not only of the most vital importance towards the success of armies, but which, in a war of sieges, such as every obstinate protracted contest must necessarily lead to, are of so very hazardous a nature, that in the common course of military events, the major part of the officers are always likely to be killed or disabled, before they can possibly have opportunities of acquiring an equal degree of practical knowledge in the field.†

Since, by reason of the improved system, which has been described, a treatise upon the attack of fortified places is no longer indispensably necessary for the use of the Royal Engineer Department,‡ I have given up the intention of undertaking it; although something of this kind may so far be deemed an essential part of Elementary Fortification, that, strictly speaking, no work bearing that title can be considered complete without it. Enough, however, has been done, in the present volumes, to qualify the reader for improving himself by further study; for after going through this Course, he will find no difficulty in comprehending the works of other writers, who have treated those parts of the subject, which I have left untouched; although, if he had not thus prepared himself, he could, as I before observed, have derived little or no benefit from them, without the assistance of a master.

* See note (D).
† See note (E).
‡ See note (F).

NOTES TO THE PREFACE.

(A) The companies of Royal Military Artificers, as the men of the Royal Engineer Department were formerly called, being raised by the Duke of Richmond, at the end of the American war, chiefly with a view to employ them as workmen in the principal fortresses in the British dominions, were not organized in such a manner as to render them also useful, in the event of a new war; and their discipline was almost entirely neglected, they being, both by themselves, and by the officers who commanded them, considered rather as civilians than as soldiers. This, I must remark, as being one of the greatest and most pernicious errors, that could have been committed; for, even allowing the mere execution of a certain quantity of labour to be the principal object of raising any military corps, which it ought not to be; it will invariably be found, that, without the greatest attention to discipline, it will no more be possible to get a body of soldiers to work well, than to fight well. If, on the contrary, their discipline is good, they may excel in both; and that is the great standard of perfection, that ought to be kept in view, in organizing the Engineer Department of any army.

At first, the Royal Military Artificers consisted of independent companies, stationed at Portsmouth, Plymouth, Chatham, Dover, Gibraltar, and other places, where works of fortification were either in progress, or under repair; and the Captain of Engineers, commanding each company, had the entire charge of recruiting it, and also of disciplining or drilling his men, as far as he or the senior Engineer at the station judged necessary—that is to say, in most cases not at all. This system, if such it could be called, was attended with the greatest inconveniences and confusion; and therefore the particular charge of recruiting for the whole Corps, was afterwards given to a Captain of Engineers, who was stationed at Woolwich, with the title of Adjutant. On their arrival at that place from the country, the recruits were clothed, equipped, and drilled, as infantry soldiers, for a certain time, under the inspection of the above-mentioned officer, who afterwards posted them to the several companies at other stations, as required. In short, they were thus put into a state, to qualify them for joining a regiment of the Line, and this was, no doubt, a great improvement upon the former system, in which no principle of soldierlike feeling, whatsoever, had been inculcated into them; but still they were left ignorant of the very important duties which, as Engineer Soldiers, they might be called upon to perform in the field. Invalids, from the various companies abroad, and at other stations, were also sent to Woolwich, previously to their being discharged; and thus that place became the Head Quarters, and the Depôt for recruits, of the Royal Military Artificers. Recently, the officer in charge of the

recruits has been called Brigade-Major, instead of Adjutant; and, independent of his practical duties, the whole correspondence of the Corps, relative to promotions and transfers of individuals, movements of companies, the circulation of general orders, &c. is carried on through him.

From the close of the American war till the year 1811, all the companies of Royal Military Artificers were kept permanently fixed at their respective stations, both at home and abroad; where they remained for life, in what may, for military men, be styled a state of vegetation: so that there were, at that period, a vast number of men, who had actually grown grey in the Corps, who had never entered a transport, nor made a single day's march from the Head Quarters of their company. To the men at Gibraltar, and other foreign stations, the service of the Corps was thus rendered almost equivalent to transportation for life. Everywhere they intermixed with civilians: they married in a proportion unknown in any other corps; — so much so, that the number of women and children belonging to one company, was often equal to that of a battalion of the Line. The superior pay, too, of the Royal Military Artificers, which in well-regulated corps, such as His Majesty's Life-Guards, &c. invariably adds to the respectability of the soldier, had of course the directly contrary effect, in a neglected one. And in the West Indies, and at Gibraltar in particular, to all those evils, which, in process of time would have broken the military spirit, and ruined the character of the best troops that ever existed, was added a most ill-judged system, of receiving volunteers from regiments of the Line going to England; — a system, by which the commanding officers of these regiments got rid of their worst men, to the prejudice of the Royal Engineer Department.

When any expedition was to be undertaken, the number of Royal Military Artificers required, were, in all cases, selected, by small detachments, out of the stationary companies; and, as the commanding Engineers at the several fixed stations were naturally averse to parting with their best men, the detachments, thus formed for field service, were generally composed of the stupidest and least trustworthy non-commissioned officers, and of the most ignorant, profligate, and abandoned of the privates. As the Gibraltar companies were, from circumstances, the worst in the Corps, the detachments, formed from them, which went to Minorca, Sicily, and other parts of the Mediterranean, were found so very inefficient, that the measure of raising Maltese Artificers was resorted to. And thus, not only were Maltese and Sicilians preferred to Britons, in the Mediterranean, for the very important service of the Royal Engineer Department; but, I am told, that, in the West Indies, it had actually been proposed to employ Negroes as Engineer Soldiers.

In the year 1811, the pernicious system of sending the non-commissioned officers and men on service by small detachments, was abandoned.

and from that time they have always moved in regular companies. The following year, the name of the Corps was changed to the more martial appellation of Royal Sappers and Miners; and an Establishment was formed, at Chatham, for the express purpose of instructing them in the field duties of the Royal Engineer Department, in a manner that is particularly noticed in another part of the Preface. To this Establishment all the recruits are sent, after being kept for a certain time at Woolwich, under the Brigade Major, where they are taught the first elements of military discipline, as was before stated; an object which is also of great importance. The officers, conducting each of these Establishments, receive orders from, and communicate with, the Inspector General of Fortifications, who has the entire charge of the Royal Engineer Department: and thus, there are two separate Institutions for the practical instruction and training of the Recruits, in one of which, they learn a part of their duty, in the other, the remainder of it; which is not the case in any other corps, or regiment. This arrangement, which originated from the peculiar circumstances, attending the first formation and progressive improvement of the Corps, does not, by any means, appear to be advantageous to His Majesty's service. On the contrary, it is generally allowed, that, by uniting the above two Establishments, or at least by carrying on all the practical duties of both, in proper concert, at one and the same station, the whole might be conducted to far greater advantage. At the same time, some expense might be saved to Government; and the men would be completed in the knowledge, both of their military and professional duties, in a much shorter space of time, which in itself would, of course, be an additional saving. In fact, there are many of the field duties, which cannot be practised to advantage, without having the use of a larger body of recruits, than it will be practicable to collect together, whilst the two Establishments remain divided. The operations at Chatham have often been paralyzed, for months, from this cause; and, indeed, owing to the same reason, during the pressure of the war, in the years 1812, 1813, and 1814, several companies were sent from thence on foreign service, less perfectly trained than could have been wished. If from these, or other considerations, the union of the two Establishments, now suggested, should ever take place, at a future period, the official correspondence relative to the general duties of the Corps, which is at present conducted, as was before stated, in the Brigade Major's office at Woolwich, might probably be carried on to most advantage in London, in the office of the Inspector General of Fortifications, by whose immediate order, all matters, to which the said correspondence applies, are entirely regulated.

At present, independent of recruits, there are very few non-commissioned officers and privates in the Corps, who have not been trained to their field duties, with the exception of two companies at Gibraltar, and of some incomplete companies at other stations, which are the only remnants left

of the Old Artificers, and which, I am informed, still retain the habits and character of that body, as described in this note. Although much has been done towards the improvement of the Royal Sappers and Miners, who leave England in a state of excellent discipline, and with the best character, there still remain very serious defects in the organization of the companies, which have a continual tendency to throw them into disorder, and to deteriorate their character and destroy their discipline. These evils, the remedies to which are of a very simple and obvious nature, will be more fully treated of in a future note.

(B) In consequence of the knowledge, thus acquired, the men, who have been instructed according to this system, have been found of the greatest service, not only in executing field works with greater skill and dispatch, but also in assisting the officers of Engineers, to superintend working parties. Indeed, on all occasions, in which works are carried on upon an extensive scale, the latter is by far the most important and useful manner, in which the men can be employed. For example, no less than about 18,000 peasants and 2000 horses worked, by order of the Duke of Wellington, under the direction of officers of the Royal Engineers, in improving the defences of the frontier of the Netherlands, for some months together, immediately before the great victory of Waterloo; and by all accounts, the extensive works, then in hand, were conducted with the greatest regularity and dispatch. Now, it may easily be conceived, that to have directed such a great body of workmen to proper advantage, by means of a few officers of Engineers, would have been utterly impossible, but for the system adopted, of subdividing the various works amongst the non-commissioned officers and privates, each of whom was made responsible for laying out the details of his own portion, and for the direction of a party of from 20 to 100 men, or even more, according to circumstances. During the last year of the Peninsular war, and in the various recent operations in Canada, the same system had been constantly practised with equal advantage; the non-commissioned officers and men of the Royal Engineer Department, who were employed as overseers of military working parties, having on all occasions given the highest satisfaction. Nor has their superior knowledge rendered them presumptuous or intractable: on the contrary, it has evidently produced the most favourable effect upon their character and conduct; and as far as regards personal exertion, it is generally allowed, that these men, although mostly composed of Artificers, will, with equal ease to themselves, perform nearly twice as much work, as any common working party of the same numbers, furnished by other troops, who have not been previously habituated to the construction of field works.

(C) To render them more expert in the last-mentioned branches of duty, which are carried on in a part of the River Medway below Chatham,

which is there subject to the action of the tides, and exceeds most inland rivers in rapidity, they are exercised in the operations of rowing, casting and weighing anchors, sheering boats by means of a current, to serve as flying bridges, &c. In consequence of their continual exertions and experience, for more than three years past, the manœuvres of pontoons, and of military bridges in general, under given circumstances, have been reduced to a system; and the practicability of any operation of this nature, with certain means, may be calculated beforehand, with a degree of precision. The smaller parts of the pontoon equipage have been improved; but the pontoons themselves, being an establishment of considerable expense, have not been altered. They are precisely the same that were used in the time of the Duke of Marlborough, having been, I believe, copied from the Dutch pattern of those days, and as such they are best calculated for still waters or moderate currents. It is true, that they are by no means unfit for general service, even in their present form; but some alteration might certainly be introduced to advantage. I am of opinion, that the whole, or at least a part of them, should be formed of copper, as being a less perishable material than the tinned iron plate at present used. Notwithstanding this change, their weight might probably be somewhat diminished, still leaving sufficient strength. Their ends should be made pointed, instead of square, which would not only cause them to ride a great deal easier in a rapid current, when the bridge is formed, but would also render them much more manageable in rowing, in which very essential purpose they must often be employed. For example, in the passage of the Adour, the Duke of Wellington was enabled to throw 500 men across the river, by means of his pontoons, used as row-boats, preparatory to the formation of a bridge of large boats, which important object could not have been effected, if the portable bridge equipage of the army had consisted of decked pontoons, or other similar expedients, that have either been used or recommended, with a view to prevent military bridges from being sunk by the extraordinary action of mountain rivers, after winter rains, or the melting of the snow. I conceive, that by the addition of light wash boards, moveable at pleasure, which may be fixed to the present pontoons, when required, so as to raise that end which is exposed to the current, the water may be effectually excluded in the most violent floods; and that thereby the pontoon, thus modified, may be serviceable in all countries, and at all seasons, both as a row-boat, and as forming the groundwork of an efficient bridge. But if, on trial, these two objects cannot be reconciled, as such very violent currents are not to be encountered in all countries, the present pontoon, with a little modification, ought still to be retained, as the best adapted for general service, whilst, on peculiar occasions, bridges of casks, that are of course incapable of being sunk under any circumstances, may be formed for the passage of mountain rivers of extreme rapidity. Seven butts, of the size used as water-casks in the

Royal Navy, are equivalent to one large English pontoon, in the formation of a bridge, and when put together in a peculiar way, to which the officers and men of the Royal Engineer Department are regularly trained, they constitute what is called a pier. One of these piers, although possessing equal buoyancy, is rather lighter than the pontoon: when the casks and other necessary materials are laid out loose on the bank of a river, it may be completely put together, and launched by a small party of expert men, in three minutes: and it may afterwards be moved in any direction by five rowers (one of whom steers with an oar). Casks fit for forming such bridges, are to be found in every country in great abundance, and may be carried on the backs of mules or horses, in roads that would be impassable for pontoons, or other expedients that require four-wheeled carriages.

The facility wherewith the officers and men of the Royal Engineer Department can now execute military bridges of any description, not only with regular pontoons, but also with country boats, casks, and a variety of other expedients, which it would be superfluous to mention, may, perhaps, justly be considered one of the greatest improvements, that has recently been introduced into the service; for it is well known, that a few years ago there was scarcely an officer in the British army, who knew any thing of this important subject, except by theory. In several foreign armies, it is usual to have distinct corps for the purpose, whose duty it is to form military bridges, and nothing else; but I conceive that such a system would be entirely inapplicable to the British service. After Lord Lynedoch (then Sir Thomas Graham) landed in Holland, at the close of the year 1813, two young lieutenants of engineers, and a company of men who had been trained to this duty, formed in a very expeditious manner a bridge of country boats over the river Maerk near Zanderbuiten, which served for the conveyance of the heaviest artillery. The boats were of different shapes and sizes, collected for the occasion. The materials for the superstructure were also of irregular scantling, and partly collected in the neighbourhood, partly felled on the spot. If the officers and men employed on this service had belonged to a regular corps of Pontoneers, they must have remained idle and useless during the remainder of that short campaign; instead of which, the greater part of them were soon after brought into action, in the attack of Bergen-op-Zoom, and afterwards in the bombardment of Antwerp; and on the renewal of hostilities in 1815, they were employed in fortifying the frontiers of the Netherlands. A corps of professed Pontoneers would be entirely useless in time of peace, and in a variety of situations, even in time of war, unless they were also made competent to the performance of other duties, of a very different nature from their own peculiar profession; and therefore, I conceive, that the system now established in the British army, of calling upon the Engineer Corps to furnish detachments for the execution of military bridges, when required, is by far the best that could have been adopted; for so long as a

regular Pontoon Train is wanted for constant service, the particular companies, ordered to be attached to it, may be kept permanently to that duty, for any number of campaigns; and as far as skill and exertion go, I feel confident that the officers and men of the Royal Engineer Department may, at this moment, enter into competition with the most expert Pontoneers of any of the Continental nations.

It is to be observed, that the advantages of the system described in the present note were not felt during the greater part of the Peninsular war, as the officers and men who had been previously trained to the art of constructing military bridges were scarcely ever employed in that peculiar line of duty, excepting in the construction of the celebrated bridge over the Adour, the executive part of which they performed in concert with the Royal Navy; and on that occasion their skill and exertions, particularly in crossing the very dangerous bar at the mouth of the river, attracted the highest praises from Rear Admiral Penrose, whose official letter on the subject was, however, from some accident or oversight, never published at full length, so that this circumstance is not generally known to the public, although their number greatly exceeded that of the seamen, who cooperated with them. I made use of the expression, "executive," because the project of supporting the superstructure of that bridge by means of hawsers, instead of baulks, according to the more common system, was, I understand, originally suggested by an officer of the Royal Staff Corps. Baulks were, however, added, in a few weeks after the first formation of the bridge, and they proved on trial much preferable to the former expedient, which is by no means well adapted to bridges of boats, or other floating bodies; although it may be used to great advantage (as it had, in fact, been by the same officer on a former occasion) in those peculiar cases, in which the clear intervals between the only points of support, that can conveniently be obtained, are of an extraordinary width or span.

(D) Owing to the very recent introduction of the system described, the trained Sappers and Miners were not brought forward in sufficient numbers, in any enterprize of importance, before the siege of St. Sebastian, in which they distinguished themselves. At the assault of Bergen-op-Zoom, in March 1814, the Royal Sappers and Miners, headed by a lieutenant of Engineers, cut down the palisades, crossed the ditches, planted the ladders, and were the first troops that mounted the enemy's ramparts. At Peronne, a place taken by storm, after the battle of Waterloo, they also had the honour of leading the assault. But the most remarkable instance, of the advantages arising from having men of this description, was in the siege of Fort Boyer, on the coast of America, which was attacked by the British troops after their failure before New Orleans. The first night of the operations, soldiers of the Line only were employed. From a want of skill and expe-

rience in the nature of the duties required of them, and there being very few Engineer officers to direct, they collected in groups, instead of being spread out, as they ought to have been. Consequently, out of one small party of twenty men, fourteen were killed and wounded by a single discharge of grape shot, and such confusion ensued, that very little progress was made in the course of that night. On the second night of the siege, nine men of the Royal Sappers and Miners were employed in addition to the troops of the Line. By assistance of these few individuals, the officers of Engineers were enabled to regulate their working party to so much advantage, that before morning they had completed a parallel of 200 yards in extent, within 50 yards of the enemy's works, besides approaches in advance, which being filled with sharpshooters, the Americans were unable to show themselves at their guns, and the fort surrendered. It is proper to explain, that, as the army sailed from the Mississippi in divisions, the main body of officers and men of the Royal Engineer Department, had not arrived at the period of the above attack. The nine men who so particularly distinguished themselves, happened to be on the spot before the others, because, being all carpenters by trade, they had been lent to the Admiral for the purpose of repairing the boats of the fleet.

(E) The loss of officers of the Royal Engineers in killed and wounded, in proportion to the total number employed, in the several sieges in Spain, was as follows. In the attack of Fort Christoval, at the first siege of Badajoz (the latter place itself being merely blockaded), 5 out of 7. At Ciudad Rodrigo, 7 out of 18. At the last siege of Badajoz, 15 out of 20. At Burgos, 3 out of 5, and all the non-commissioned officers and soldiers of the Department present. At St. Sebastian, 11 out of 18. For further particulars of these operations, see Lieut.-Col. Jones's Journals of the Sieges in Spain. In the numerous general actions and skirmishes, in which the British Engineers have also been present, during the late wars, their loss has been very trifling compared with the above. For example, although 6 officers of the Royal Engineers were engaged in the battle of Maïda, and 5 served on board Lord Exmouth's fleet, in his late brilliant attack on Algiers, not one out of the whole number was hurt on either of these occasions. But the peculiarly hazardous nature of the Engineer's duty in sieges is proved, not merely by our own military history, but also by that of other European nations, as will be seen by referring to Allent's History of the French Corps of Engineers. In the second attack of Saragossa, 15 out of 27 Engineers of the besieging army were killed and wounded; and in the event of new wars, at least an equal proportional loss of Engineer Officers is always to be expected, as a matter of course, in every well-contested siege. Hence it may be allowed, that every precaution, that human prudence can dictate, ought to be taken for rendering

a Corps of Engineers effective in the field; their garrison duties, although of great importance, being of a very secondary nature, compared with those that they are called upon to perform in war.

(F) A brief view of the past and present Field Establishment of the Royal Engineer Department will show the great improvements, that have recently taken place in this very important branch of our national military service.

During the whole of the war, which was terminated by the peace of Amiens, and in the first expeditions subsequent to the renewal of hostilities, and even during several of the Peninsular campaigns, the officers of Engineers, employed in any siege or other enterprize of importance, seldom had more than twenty or thirty Royal Military Artificers under their orders, and all attempts to render these men useful were attended with disappointment, owing to their total want of previous instruction in the nature of the field duties of the Department. The discipline of the Artificers was also, from causes which were partly explained in a former note, much inferior to that of other British troops; but, low as they stood in public estimation, it must be allowed, to their credit, that they always proved themselves to be possessed of an ample share of the national courage.

Independent of the difficulty, just stated, which the officers of Royal Engineers laboured under, in not having a sufficient body of well disciplined, and well instructed soldiers, to act under their orders, another deficiency of a no less serious nature affected the Department, in the total want of the means of transport for necessary stores. Even the pontoons, sent out with our expeditions, were merely consigned, by order of the Board of Ordnance, to the commanding Engineer, like other articles of store, without any provision of properly trained men for manœuvring them, and without any establishment of drivers and horses for transporting them. Consequently in cases of emergency, either country drivers, &c. were to be hired, and horses bought, at a disadvantage; or men were to be borrowed from the Infantry, and the means of transport from the Artillery or Commissariat. These temporary expedients created the greatest confusion, and generally tended, for the time being, merely to paralyze other important branches of the service, without by any means producing proportional benefit to the Royal Engineer Department, the officers of which, in consequence of the imperfect system, that has been described, not having the requisite means for conducting their arduous duties in the field, with a fair and reasonable prospect of success, had their bodies on all occasions harassed by unnecessary fatigue, and their minds tormented by constant apprehensions of the failure of every enterprize in which they were engaged.

When the Duke of Wellington was making preparations for his late and most glorious campaign, the experience of former defects, which had been deeply felt in the Peninsular war, led to the following more perfect organiza-

tion of the Field Establishment of the Royal Engineer Department. Every division of the army had one Engineer's brigade attached to it; each brigade consisting of a complete company of well-trained Sappers and Miners, with drivers, horses, and waggons, carrying intrenching tools, sufficient to employ a working party of 500 men, besides a proportion of Artificers' tools, and other Engineers' stores. A captain and a certain number of subaltern officers were attached to each brigade, and were responsible for the discipline of the men and efficiency of the horses, &c. whilst the remainder of the Engineers were left free for the general duties, that might be required of them. Five companies of Royal Sappers and Miners were employed with the Pontoon Train, which consisted of 80 pontoons, besides store waggons, &c., and was drawn by nearly 800 horses, the whole being under the command and charge of a brevet-major of Engineers, assisted by a due proportion of captains and subalterns of the same corps.

To give an idea of the total strength of the above Establishment, I shall remark, that more than 20 officers having been left on duty in the Netherlands and on the frontiers, the number of Engineer officers serving with the army in France was only 41. They had under their command upwards of 800 Sappers and Miners, and 550 drivers, and had charge of 160 waggons (pontoon carriages included), and more than 1000 horses. An Assistant Ordnance Commissary with 6 clerks and 9 conductors of stores also served with the Engineer Department, besides a proportion of Medical Officers; and to each division of the Pontoon Train, were attached a small number of Flemish seamen, accustomed to rivers, and coasting navigation; but I am informed by an officer of Engineers, who was employed in the construction of two bridges, thrown over the Seine, near Paris, by order of the Duke of Wellington, that these seamen, owing to their want of previous training, were not by any means so serviceable as the Royal Sappers and Miners.

The Drivers were however the only decidedly defective part of the above establishment. About one third of them belonged to the Corps of Royal Artillery Drivers, and were only transferred to the Engineer Department, a little before the opening of the campaign. The remainder, being men hired for the occasion, in the neighbourhood of Antwerp and Brussels, were generally ignorant of their duty, and many of them of bad character, so that frequent desertions took place. However, by the great attention of the officers of Engineers, the horses were kept efficient and in proper condition; for as soon as any of the country drivers deserted, an equal number of men of the Royal Sappers and Miners were substituted in their place, who, from their peculiar habits of zeal and exertion, made no difficulty in reconciling themselves to the novel occupation of grooms and drivers. But for this measure, a number of valuable horses must have been ruined, and the Pontoon Train, as well as the Engineers' brigades, would by degrees have become totally unserviceable; and if such was the inefficiency of the

hired drivers, in so uniformly prosperous a campaign, what could have been expected from them, had the army met with any of those reverses, which are usual in war?

It is now generally allowed, that a body of proper Engineer Drivers is absolutely necessary towards the efficiency of the Department, there being the strongest objection, as was before stated, to the expedient of borrowing men from other military corps; and experience, not merely in the late short and brilliant campaign, but also on many former occasions, having fully proved, that little or no dependence can be placed in the services of hired or contract drivers, particularly foreigners. The Engineer Drivers should form a component part of the companies of Sappers and Miners, to be, like them, solely commanded by officers of the Royal Engineers, who should be held responsible, not only for the discipline of the men, but likewise for the efficiency of the horses. If this measure were carried into effect, the title "Sappers and Miners," which even at present is entirely inapplicable to many important duties of the men so styled, would be still less suitable to a corps, also containing a proportion of Drivers. It should therefore be abolished, and the whole of the men should be called Engineer Soldiers, and considered an integral part of the Corps of Royal Engineers.

Although the present is certainly not the time, in which the formation of any new military establishment can with propriety be recommended; still the measure now suggested, of raising Engineer Drivers, should always be kept in view, it being indispensably necessary, that it should be put into immediate execution, whenever the nation shall again be involved in war. And in the mean time, a great improvement might take place, without waiting for that probably remote period, by transferring the Royal Artillery Drivers, who are at present attached to the Engineer Department, in the British army in France, in a permanent manner, to the latter department; which may be effected, by allowing those men, who are inclined, to volunteer their services. A small expense, not exceeding one guinea per man, may at first be incurred by this measure, which will be amply repaid by the greater efficiency of the men and horses; for as I implied before, borrowed troops lent by one department to another, can never enter with proper zeal into the execution of, what they must consider, an extra and temporary duty. Jealousies and collisions will sooner or later take place between the officers of the two combined corps, to the prejudice of the service; and there are many reasons, why a department, amalgamated out of discordant materials, can never be in good order.

In the event of Engineer Drivers being raised, in the course of a new war, it would not be proper to discharge the whole of them, at the termination of hostilities; because the elements of every military body, which is essential in war, should be kept up in a certain proportion, no matter how small, even in time of peace. In that case, as there might not always be

employment for the Engineer Drivers in their own peculiar line of duty, they should be made useful in the construction and repair of military works, and in all such services, as are commonly performed in garrisons, by direction of the officers of Royal Engineers; and in order to qualify them for these last-mentioned duties, they should, on entering the service, not only be taught the care of horses, but should also receive the same instruction, both theoretical and practical, as the other privates.

The Engineer Drivers should be divided into Sections, or small organized bodies, each consisting of not more than twenty non-commissioned officers and privates, to be mustered always with some company of Engineers, the name or number not only of the Company, but also of the particular Section or Sections of Drivers attached to it, being specified in the heading of the muster roll. In all cases, the captain commanding the company, and his officers, should be responsible for the discipline and efficiency of the whole. In general, one section of Drivers per company of Engineers would be sufficient for field service, which arrangement would render the Brigades quite effective; but in the Pontoon Train, as the number of Drivers would require to be nearly equal to that of the other soldiers, it would probably be necessary to attach four sections of Drivers to each Engineer company. This would render the aggregate of the companies rather unwieldy, not much less than 180 men, and about the same number of horses; but when we consider, that all the troops of Horse Artillery on the war establishment were nearly as numerous, and yet that they have always been kept in excellent order, I entertain no doubt of equal efficiency; since the organization I suggest, in regard to the proposed Engineer Drivers, is founded on the system of that branch of the service, which has always given the greatest satisfaction; whilst the very contrary system, hitherto followed, in organizing the Drivers attached to the Foot Artillery, has been attended throughout the whole course of the late wars, with nothing but evil and confusion. It is true, that a considerable improvement has recently been introduced in regard to the Foot Artillery Drivers; but even this new system alluded to, appears to me to fall very far short of that of the Horse Artillery. In forming Engineer Drivers, the one or the other of the above systems will probably be imitated, and therefore I may be pardoned for stating my opinion as to which of the two ought to have the preference, which otherwise I should not have presumed to do.

I shall observe, that in the above suggestion for raising Engineer Drivers, my chief object has been to guard against their being formed into a distinct or separate Corps, from the other soldiers of the Department. To prevent even the possibility of their being considered as such, which I am persuaded would be attended with most pernicious effects to the service, I shall further state my opinion, that there ought to be no special Commandant, or field

officers, attached to the Engineer Drivers in particular; that these men should never even nominally be divided into Troops or large bodies; that there should be no officers mustered as captains of troops, nor any other commissioned staff officers, nor staff appointments whatever, to distinguish the Drivers as a separate establishment.

In short, they should be, as I said before, an integral part of the Engineer Companies, to which they are attached, for the time being; and my only object in recommending them to be divided into Sections was, in order that they might always be disposable and moveable from one company or service to another, according to the exigencies of war; an object, which could not be effected without throwing them into a state of complete confusion and indiscipline, if they were organized in any other manner whatever. For every officer of experience knows, that smaller detachments, formed out of troops or companies, always fall into bad order; and therefore in a body of men, such as the Engineer Drivers, who, from the nature of their service, must necessarily act in very small numbers, it must be allowed, that the only mode of preventing this evil, in establishing such a corps, is to divide it, as I have suggested, into organized bodies, each complete in itself, but not exceeding in number the smallest detachment, that is likely to be required to act together. If this arrangement should be carried into effect, it will of course be understood, that some Engineer companies may have no Drivers attached to them, others may have one section each, whilst others again may have two or more sections serving with them, according to circumstances. I shall conclude by observing, that all transfers of sections from one company to another should be avoided, except in case of absolute necessity.

With regard to the measure above suggested, of changing the name of the Corps of Royal Sappers and Miners, I have long been convinced, that it would be of the greatest possible benefit to His Majesty's service. The unfortunate system, which has hitherto prevailed for more than thirty years, of calling the officers of the Royal Engineer Department by one name, and the soldiers whom they command by another, in imitation of the French, was, in my opinion, the principal cause of the acknowledged indiscipline and irregularity of the old Military Artificers, and has been one of the chief obstacles to the improvement of the Royal Sappers and Miners. Even if experience had not proved, in the strongest manner, what I now assert, it might easily be conceived, on a little reflection, that any distinction, although only in name, which tends to disunite officers and their soldiers, cannot but fail to be highly pernicious to the reputation and efficiency of the whole. For when the former are known by one name, and the latter by another, the fame arising from their mutual exertions is necessarily divided, and therefore diminished; and in case the discipline and comforts of the men should be neglected, which is much more likely to

happen under this system than under any other, the disgrace will most unjustly fall solely upon the soldiers, who, as a body, have not the power of improving or organizing themselves, instead of being attached, as it ought to be, to the officers who command them. If we duly weigh this most serious disadvantage, under which the present Royal Sappers and Miners labour, and take further into consideration, that it has hitherto often been their hard fate to have a total change of captains of companies every two or three months; the excellent character which they possess as a corps, under such very unfavourable circumstances, must be allowed to do them the highest honour. If these evils, which affect no other regiment in His Majesty's service, were removed, I feel persuaded, that the Non-commissioned Officers and Soldiers of the Royal Engineer Department, as they are now the most intelligent, would also be considered the most useful and respectable body of troops in the world.

The measure, necessary for completing the proper organization of the Corps in general, is to attach one captain and two lieutenants of Engineers to each company, who shall, under all circumstances, move with their respective companies, and remain with them until promoted. The companies of the Pontoon Train only, as being more numerous than the others, ought to have three Lieutenants of Engineers attached to each. It is the common opinion, that the junior second captains of the Corps of Royal Engineers should have the command of companies in preference to senior second captains or first captains, the former arrangement being by far the best adapted for the general service of the Corps in active warfare, and therefore the one which might on that ground be with most propriety adopted, even in time of peace or in garrisons. The reason, which may perhaps appear sufficiently obvious, is as follows. It is well known that the duties of the commanding Engineer, serving with a division of an army in the field, who is usually a first captain in the Corps, are so very important and extensive, that they, at all times and under all circumstances, are sufficient to engross the whole of his attention; so that if the command and charge of a company of soldiers is also made to devolve upon him; (as no individual, however zealous and indefatigable, can perform impossibilities), the unfortunate company, of which he is the nominal captain, must necessarily be neglected. The second Engineer of the division, on the contrary, not having, like the former, the general charge of a department, has it in his power, if placed at the head of a company, to pay every attention to the men under his command. At the same time, it is to be observed, that the regimental duties, thus imposed upon him, will by no means prevent him from having opportunities of distinguishing himself as an Engineer. For in sieges, and in all other operations of peculiar danger and difficulty, such as are likely, if successfully executed, to add to the credit of the Corps, the Engineer Soldiers with the Officers, who are in the immediate

command of them, must, of necessity, always be brought into action in the most conspicuous and important situations.

Although, therefore, it may be of small importance, whether the command of Engineer companies is given to first or second captains, so long as they remain stationary in garrisons; still I conceive, that it would be dangerous, and eventually pernicious to his Majesty's service, to adopt the former arrangement, even in time of peace. For the experience acquired in war is soon forgotten, unless the fruits of it are embodied in permanent institutions, so that if first captains of Engineers are appointed to the command of companies at the present moment, it is not likely that a different arrangement would be adopted, or even thought of, in case of a new war, at some future period; and therefore the moment that a British army shall again take the field, that is to say, at the time, of all others, when the good of the service requires, that the discipline and comforts of military men should be watched over with the greatest zeal and attention; the non-commissioned officers and soldiers of the Royal Engineer Department would once more be almost totally neglected, as they were in general, owing to the same cause, during the whole of the Peninsular war, a thing, which I do not scruple to assert, for it is proper that the truth should be known, the more especially as the evil arose entirely from the defective nature of the system followed; and no blame whatever can be imputed to the individual officers then in command of companies. Having now discussed most of the other points, which appear essential towards the more perfect organization of the Royal Engineer Department, I shall conclude by observing, that the class of officers, called Sub-lieutenants, who are raised from the ranks, one to each company, ought to be abolished; for many strong reasons, which I shall not enter into at large. Suffice it to say, that although the individuals selected have always been chosen on account of their merit, and some of them have distinguished themselves afterwards as commissioned officers, still it must be allowed, that the experience of ten years has fully proved, that none of the advantages expected from this measure have been realized: on the contrary, it has materially conduced to retard the improvement, and to injure the reputation and efficiency of the Corps. Some other means should therefore be adopted of rewarding the most deserving non-commissioned officers, which might be done with much less expense to the country, and at the same time more to the comfort and satisfaction of the individuals themselves, who, to my certain knowledge, have more often been involved in difficulties and distress, than really benefited, by the change.

In recruiting the Corps, the greatest attention should always be paid to character; for an idle or profligate man, who might be rendered serviceable in a regiment of the Line, is literally useless in the Royal Engineer Department; and no volunteers from the militia, nor any

discharged men from other regiments or corps, should on any account be inlisted; for it may easily be conceived, that men, who have been accustomed for years to the less laborious duty of mounting guards, and attending parades and occasional drills, can seldom be thoroughly reconciled to those steady habits of continual personal exertion, which are required of a soldier in the Engineer Department. Accordingly, it has been remarked, that young recruits, who never served before, have generally proved more intelligent and more regular in their conduct, and have apparently taken much more pleasure and pride in their peculiar duty, than volunteers from other regiments, of whom there is also a considerable proportion in the Corps. Considering, moreover, the great skill and zeal which are indispensably necessary, and the peculiarly hazardous and sometimes confidential nature of their duties, no foreigners ought, on any account, to be inlisted as Engineer Soldiers; nor should any foreign companies in future be raised. Out of three Maltese companies that were embodied about the year 1805, as alluded to in a former note, two have been already disbanded; and it is to be presumed, that the reduction of the third will soon follow.

It is proper to explain, that in the various suggestions contained in this note for the further improvement of the Department, in which I have the honour of serving, I lay little or no claim to the merit of originality, excepting in the proposal for calling not only the officers, but also the non-commissioned officers and soldiers of the Department, by the general title of Royal Engineers. All the other points treated of have, for a great number of years, been the topic of constant discussion amongst the officers of the Corps; and although opinions may vary as to details, yet the propriety of most of the general principles, that have been advanced, is now universally acknowledged; particularly as far as regards the necessity of raising Engineer Drivers, and of attaching a due proportion of officers, in a permanent manner, to the existing companies. Indeed, I know, that both of these important measures have been sanctioned by the highest authorities in the Corps of Royal Engineers, and the latter in particular is even said to be, at this moment, under official consideration; so that there is some prospect of its being soon carried into effect, the more especially, as notwithstanding the vast advantages, which must necessarily result from it, the execution of it will be a matter of mere arrangement, not involving any expense whatever to the country. I may conclude by observing, that I have not been biassed, in any thing that I have said, by the customs or institutions of any foreign nation, a blind imitation of which, in military affairs, has always appeared to me a matter to be highly deprecated. At least, so far as regards the very important field duties, at present executed by the Royal Engineer Department in the British service, I feel persuaded, that an exact copy of either the French or Austrian system, &c. of performing the same duties, would lead to a perfect chaos.

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The Five Plates are to be placed at the end of Vol. II.

In folding Plate V, the upper part of the plate must first be doubled down.

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COURSE

OF

ELEMENTARY FORTIFICATION,

&c.

THE following Course of Elementary Fortification may be conducted in the same manner, as the Practical Geometry, &c. contained in the first volume.

After every paragraph is read or explained, and the operations therein prescribed are performed, the Learner ought to write successively all those words or phrases, contained in it, which are printed in capitals, before he proceeds to a new paragraph.

By this means, after going through every chapter, he will have before him a collection of all the definitions or technical terms, that have been treated of in that portion of the work. He should then lay aside the book, and read over what he has written. If he finds that he understands the whole of his terms, and that he can readily point out, on the corresponding plan, section, or other figure, such lines, angles, &c. *as are denoted by them, he may then proceed to another chapter: but if he be deficient in respect to any of the terms, he should refer again to the book, and make himself master of the whole of them before he goes farther.*

In like manner, after drawing the plans, sections, or other figures of fortification, contained in any part of this work, he ought to examine himself in respect to the lines, angles, &c. therein delineated.

Each of these has its distinct name, which is regularly explained. If therefore, on inspecting his figures, he meets with any line or angle, the name of which he cannot recollect, he ought to return to the same chapter, and peruse it again with greater attention before he proceeds to another.

The above remarks are intended chiefly for the guidance of those, who may commence studying this Course without the assistance of a master. In teaching others, the directions given in Vol. I. at the conclusion of the Course of Practical Geometry, should be adhered to.

CHAP. I.

PRELIMINARY DEFINITIONS.

Fortification is the art of constructing military works, whether offensive or defensive.

Offensive fortification comprehends the various works, which are necessary for forwarding the operations of a besieging army.

Defensive fortification comprehends such works, as are calculated to enable a body of men, to defend themselves against a greater number.

Defensive fortification may consist either of permanent or temporary works.

Permanent works comprehend fortresses erected for the protection of cities, towns, naval and military arsenals; or for the purpose of occupying important roads, passes, or positions, which, if left open, would be favourable to the operations of an enemy.

Permanent works are either built of masonry, or otherwise constructed in a substantial durable manner, as is implied by their name.

The art of constructing works of this description is called PERMANENT FORTIFICATION.

TEMPORARY WORKS OR FIELD WORKS comprehend such works as are thrown up in haste, during a campaign, to strengthen the position of an army, corps, or detachment.

The art of constructing such works is called FIELD FORTIFICATION.

Permanent works are inclosed all round; and from the strength of the obstacles, which they oppose to an enemy, are such as cannot be taken without a regular siege, provided that they are furnished with a proper garrison and stores.

Field works, being generally intended to strengthen the position of troops drawn up in order of battle, are often left open or defenceless in rear; and from the hasty nature of their construction, they are frequently liable to be taken by storm.

The study of fortification is usually divided into two distinct branches, elementary and practical.

ELEMENTARY FORTIFICATION teaches the method of planning a fortress according to certain rules, proportions and dimensions; besides which it also includes the art of planning the operations of a siege.

PRACTICAL FORTIFICATION teaches the nature and use of the various materials and implements used in constructing works, together with the quantity of each kind, that will be necessary: also the number of workmen required, and the best mode of distributing and directing them: lastly to calculate the probable expense of a work, and the time likely to be required in finishing it with certain means.

In short: Elementary Fortification includes every particular relative to the plan of works; whilst Practical Fortification embraces all details respecting the execution of them. The former branch requires more talent, but both are so intimately connected, that an Engineer cannot hope to succeed in planning works to advantage, without a knowledge of the executive part.

In order to simplify the study of Fortification, it is always supposed, in the first instance, that the place to be fortified is situated on a level plain; in which case, it will be evident, that the works ought to be of the same strength all round, and disposed according to some general and uniform plan.

A place thus fortified is called A REGULAR FORTRESS.

CHAP. II.

OF THE OUTLINE OF A REGULAR FORTRESS.

A regular fortress is inclosed all round by a continued WALL OR RAMPART.

THE INCLOSING WALL OR RAMPART OF A FORTRESS is not built in a circular form, or according to any continued curved line; but is usually constructed with angular or projecting parts, at certain intervals.

These projecting parts are called BASTIONS.

The bastions, or projecting parts of the walls of a regular fortress, are joined by other more retired portions, laid out in right lines.

These retired and right-lined portions of the walls of a regular fortress are called curtains.

The outline of a regular fortress is, therefore, composed, partly of bastions, and partly of curtains.

I shall now teach you to draw a bastion.

The plan of a bastion is traced by four right lines joined together; of which two are called FACES, and two are called FLANKS.

Draw a right line perpendicularly, that is to say, in a direction from the top towards the bottom of your paper, to represent THE LEFT FLANK OF A BASTION.

Draw a second line from the top of the former towards the right, and so as to form an obtuse angle with it.

This second line is to represent THE LEFT FACE OF THE BASTION.

From the extremity of the left face of your bastion draw another line, also towards the right, so as to form a right angle nearly.

This third line is to represent THE RIGHT FACE OF THE BASTION.

From the extremity of the right face of your bastion, draw another right line downwards.

This last drawn line will represent THE RIGHT FLANK OF THE BASTION, which is therefore complete.

Draw a second bastion, similar to the first, a little to the right of it, and lower down your paper.

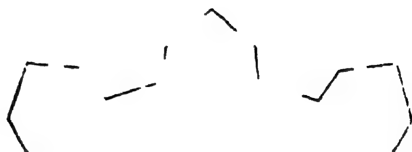
Join the lower extremities of the opposite flanks of your two bastions by a right line.



* The last drawn line is called A CURTAIN, as was before mentioned.

Draw a third bastion to the left of the former, also a little lower than the first drawn bastion.

Draw a curtain to connect it with the adjoining bastion.

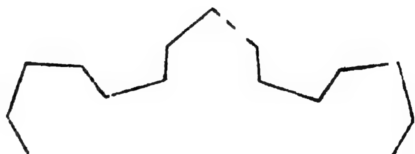


What you have now drawn represents part of the outline of a fortified place, and, it must be evident, that by adding more bastions and curtains, you might produce the right and left extremities of your figure, until they met each other, so as to inclose a space, such as would be contained within the walls of a fortress.

All the angles in the outline of a fortified place have their particular names.

The angle, formed by the two faces of any bastion, is called THE SALIENT ANGLE OF THE BASTION.

Mark the salient angle of your center bastion by a small arc.



The angular point of the salient angle of a bastion is sometimes simply called THE POINT OF THE BASTION.

The angle, formed by a flank and a face of any bastion, is called THE ANGLE OF THE SHOULDER.

Mark the angles of the shoulder of your right and left bastions.



The angular points of the last-mentioned angles are sometimes simply called THE SHOULDERS OF THE BASTION.

Consequently there is THE RIGHT SHOULDER OF A BASTION, and THE LEFT SHOULDER OF A BASTION.

The angle, formed by the flank of any bastion and an adjoining curtain, is called THE ANGLE OF THE FLANK.

Mark the angles of the flank of your center bastion.



Rub out your marks.

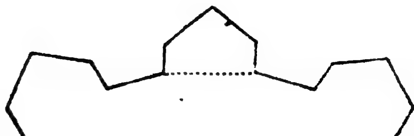
In addition to the lines shown in your present figure, it is convenient, in drawing the outline of a regular fortress, to use a number of other lines, which do not actually appear on the ground when the work is finished.

These imaginary lines are drawn in pencil, in constructing the plan of a fortress. Afterwards, in penning it with ink, they are either rubbed out or dotted.

A line supposed to be drawn between the two angles of the

flank of any bastion, so as to inclose it in rear, is called THE GORGE OF THE BASTION.

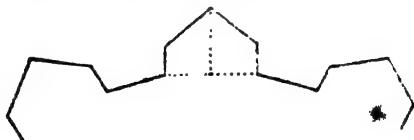
Draw a dotted line to represent the gorge of your center bastion.



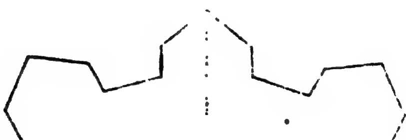
The gorge of a bastion is sometimes also called THE REVERSE OF THE BASTION: and in general the reverse of any work whatever signifies the rear of it.

A line, drawn through the salient angle of any bastion so as to bisect it, is called THE CAPITAL OF THE BASTION.

Draw a dotted line to represent the capital of your center bastion.

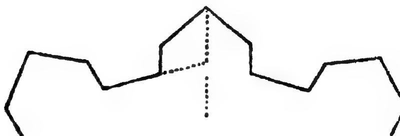


Rub out the gorge of your center bastion, leaving the capital.

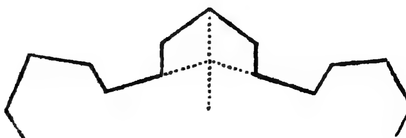


THE DEMIGORGES OF A BASTION are formed by producing the adjoining curtains, until they meet the capital of the bastion.

Draw the left demigorge of your center bastion.

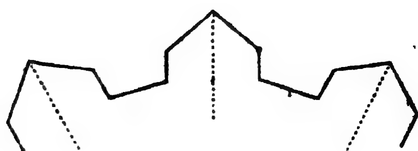


Draw the right demigorge of the same bastion.



Rub out the demigorges of your center bastion:

And draw the capitals of the right and left bastions of your figure.



The capital of a bastion divides it into two equal parts, which are called DEMIBASTIONS OR HALF BASTIONS.

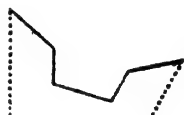
A FRONT OF FORTIFICATION consists of any two opposite demibastions, and one curtain, namely that which lies between them.

Rub out the left face and left flank of your left bastion, and the right face and right flank of your right bastion.



Two fronts of fortification now remain.

Rub out one of them.



One front only now remains, consisting of two demibastions, and one curtain, as was before explained.

The continued wall or rampart, which incloses a regular fortress all round, forms what is called THE BODY OF THE PLACE, OR MAIN INCLOSURE.

The body of the place is surrounded by a ditch, which is called THE PRINCIPAL OR MAIN DITCH OF THE FORTRESS.

In fortification, the interior side of any ditch, that is to say, that side or boundary of it, which is nearest to the center of the fortress, is called THE SCARP.

But the exterior side of a ditch, that is to say, that side or boundary of it, which is nearest to the country, is called THE COUNTERSCARP.

Small works, called TENAILS, are usually constructed in the main ditch of a fortress, in front of, and near to, the curtains of the body of the place.

A tenail consists of two faces, which form an obtuse angle inwards, or towards the center of the fortress.

Draw two lines, forming an obtuse angle downwards, to represent the RIGHT AND LEFT FACES OF A TENAIL.

A tenail has two demigorges in rear of and parallel to the faces.

Draw two lines near the former, below them, and parallel to them, and of the same length nearly, to represent THE DEMIGORGES OF THE TENAIL.



Join the opposite ends of these parallels by right lines.



The last drawn lines form what are called THE EXTREMITIES OF THE TENAIL.

Your tenail is now complete. It has two faces, two demigorges, and two extremities.

The angle formed by the two faces is called THE REENTERING ANGLE OF THE TENAIL: and, generally speaking, all angles, in fortification, which point inwards or towards the center of the fortress, are called reentering angles.

Sometimes the faces of a tenail are not produced until they meet, but are joined by a third line, which is called THE CURTAIN OF THE TENAIL.

Draw the front of a new tenail, with two faces and a curtain.



Draw lines parallel to and in rear of the former, to represent the reverse of your new tenail.



Draw the extremities of your new tenail.



The tenail, which you have now drawn, is called A TENAIL WITH A CURTAIN.

A tenail with two faces only, such as you drew before, is called A SIMPLE TENAIL.

Besides the tenail, there are usually some detached works, advanced beyond the main ditch of a fortress, which, from that circumstance, are called OUTWORKS.

The most simple and common kind of outwork in use is called A RAVELIN.

A ravelin has two faces forming an angle outwards, or towards the country.

Draw two lines forming an angle upwards, to represent THE RIGHT AND LEFT FACES OF A RAVELIN.



The angle, formed by the two faces of a ravelin, is called THE SALIENT ANGLE OF THE RAVELIN: and generally speaking, all angles in fortification, which point outwards or towards the country, are called salient angles.

The angular point of the salient angle of the ravelin is also called the POINT OF THE RAVELIN.

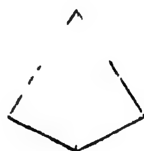
In addition to its two faces, the ravelin has also two demigorges, which form a reentering angle, that is to say an angle pointing inwards, as was before explained.

Draw two lines to represent THE RIGHT AND LEFT DEMIGORGES OF THE RAVELIN.



THE CAPITAL OF A RAVELIN is an imaginary line supposed to bisect it, and passing through the salient angle.

Draw a dotted line to represent the capital of your ravelin.



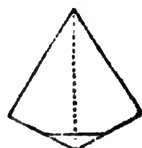
It is to be observed that the term "capital" is not confined to bastions and ravelins only: it may also be applied to other works of fortification, and always signifies an imaginary line, passing through the salient angle of a work, and bisecting or nearly bisecting it.

In like manner, the terms "gorge" and "demigorges," may be applied to other works of fortification, besides those which have been above described; it being observed, that they always signify lines, which are supposed to inclose the work in rear or in reverse.

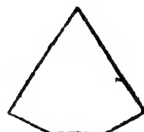
The ravelin, which you have just drawn, is called A SIMPLE RAVELIN.

Sometimes the two demigorges of a ravelin are not produced till they meet; but the reentering angle is cut off by a right line perpendicular to the capital.

Draw a right line accordingly to cut off the reentering angle of your present ravelin.



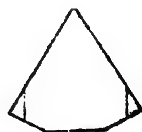
Rub out the superfluous parts of your former demigorges: rub out also the capital of your ravelin: and the ravelin will be complete in its new form.



The last drawn line is called THE BREAK AT THE GORGE OF THE RAVELIN.

Sometimes a ravelin has small flanks, which are made parallel to the capital or nearly so.

Draw two lines, accordingly, to represent the flanks of your ravelin.



Rub out those lines of your present figure, which will become superfluous after the flanks are drawn.



The figure of A RAVELIN WITH FLANKS is now complete.

Ravelins without flanks are esteemed the best.

The ravelins of a fortress are always placed before the curtains, and beyond the main-ditch; consequently they stand immediately in front of the tenails.

In a regular fortress, there is not only the main ditch surrounding the body of the place; but there are also ditches in front of the ravelins and other outworks.

The ramparts of the body of the place are usually raised higher than those of the outworks; and the main ditch is in like manner almost always broader, and sometimes deeper than THE DITCHES OF THE OUTWORKS.

Beyond the ditches of a fortress, there is usually a narrow space left all round, which agrees with the natural level of the original ground nearly.

This space is called THE COVERED WAY.

Immediately beyond the covered way the earth is raised to such a height as to protect a man standing in it (that is to say in the covered way) against distant shot fired from the country.

This elevated part in front of the covered way is called THE GLACIS.

The glacis, which is higher than the natural level of the ground on one side, falls off with a gradual slope towards the country on the other side, until it meets the said ground level.

To recapitulate: a regular fortress has walls or ramparts, and ditches. There are the ramparts of the body of the place, and the ramparts of the outworks. In like manner there is the main ditch,

that is to say the ditch of the body of the place, and the ditches of the outworks. Beyond the ditches is the covered way; and lastly the glacis.

The nature of these works will best be understood, from the consideration of their section or profile, which I shall next proceed to explain.

CHAP. III.

OF THE SECTION OR PROFILE OF THE VARIOUS PARTS OF A FORTRESS.

The first line drawn in every section or profile is the ground line, which is intended to represent the natural surface of the ground, upon which the fortress is constructed.

In the section of a regular fortress, this line is always supposed to be perfectly level, or horizontal.

Draw a line across your paper to represent THE GROUND LINE of your section.

In the section of every regular work, there is the rampart, ditch, covered way, and glacis.

The rampart has an inside, a terreplein, a parapet, and a scarp.

The inside or back of the rampart, being generally of earth, has a slope, which is called THE INTERIOR SLOPE OF THE RAMPART.

The interior slope of the rampart has a base and a height.

Mark the base of the interior slope, upon your ground line, by two points.



Represent the height of your interior slope by a perpendicular raised above the ground line, from the second point.



Draw an oblique line between the first point and the top of the above perpendicular.



The line last drawn represents the interior slope of your rampart.

The terreplein is the level part or terrace of the rampart, upon which the guns and mortars, destined for the defence of the fortress, are placed.

It commences immediately in front of the interior slope of the rampart.

Mark the extent of the base of your terreplein, upon the ground line, by a point.



The terreplein is made a little higher in front than in rear, to prevent rain water from lodging upon it.

Represent the height of your terreplein in front, by raising a perpendicular from the above point.



Draw a right line, connecting the top of this perpendicular, and that of the interior slope of the rampart.



The last drawn line will represent THE TERREPLEIN of your rampart.

THE PARAPET is a breast work, constructed upon the front of the rampart, and raised to a certain height, to protect the men and guns, placed upon the terreplein, against an enemy's fire.

The parapet has an inside, a top, and an outside.

The inside of the parapet generally has a slope, which is called the interior slope of the parapet.

Represent the height of your parapet above the front of the terreplein, by a vertical line; or, in other words, one which is perpendicular to the ground line of your figure.

This is done by producing upwards that perpendicular, which shows the height of the terreplein in front.



Represent the base of the interior slope of your parapet, by marking a point upon the terreplein, at a short distance in rear of the last drawn line.



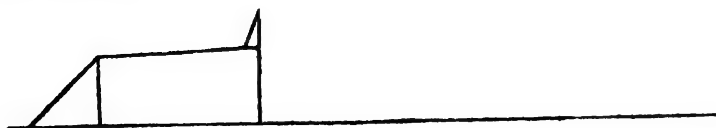
Draw THE INTERIOR SLOPE OF THE PARAPET.



The top of the interior slope of the parapet is called the interior crest of the parapet.

Sometimes it is simply called THE CREST OF THE PARAPET.

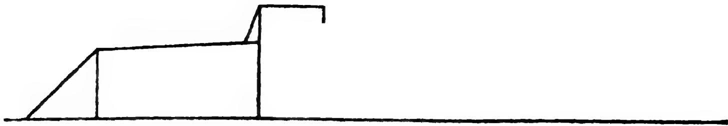
From the crest of the parapet draw a horizontal line, outwards, to represent the thickness of the parapet at top; it being of course understood, from what was said before, that every horizontal line, in the section of a regular fortress, is supposed to be parallel to the ground line.



The top of the parapet has a gentle slope from the crest downwards, which is called the superior slope.

Represent the height of the superior slope of the parapet by

dropping a perpendicular from the extremity of the last drawn line.



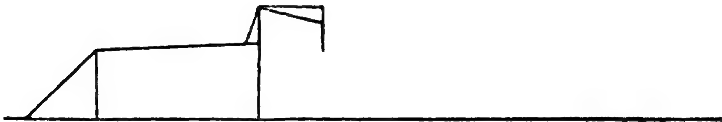
The height of the superior slope of the parapet is also called THE DIP OF THE PARAPET.

Draw THE SUPERIOR SLOPE OF THE PARAPET.



The outside of the parapet has a slope which is called the exterior slope of the parapet.

Produce the dip of the parapet downwards to a certain extent, to represent the height of the exterior slope of the parapet.



From the foot of this produced line, draw a horizontal line, outwards, to represent the base of the exterior slope of the parapet.



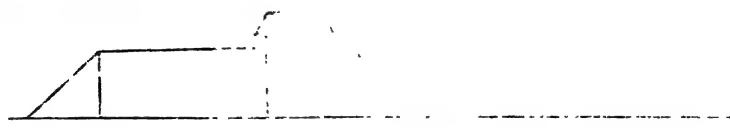
Draw THE EXTERIOR SLOPE OF THE PARAPET.



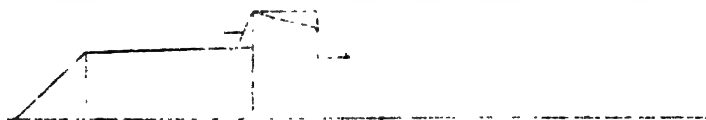
On that part of the terreplein, which is immediately behind the parapet, there may either be gun and mortar batteries, or a banquette.

THE BANQUETTE is a foot bank for the troops to stand upon, when they fire over the parapet with small arms.

Represent the level of the banquette by marking a point, on the interior slope of the parapet.

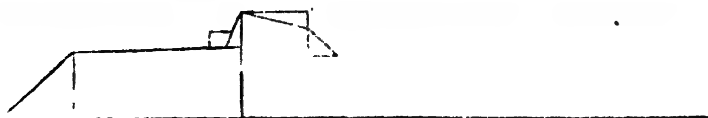


From this point draw a line backwards, which may be horizontal or nearly so; in order to represent the breadth of the banquette.



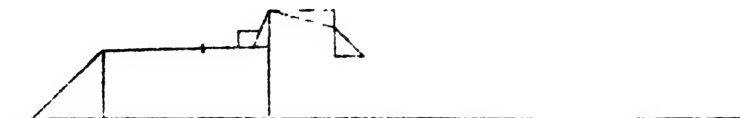
This line is called THE TREAD OF THE BANQUETTE.

Represent the height of the banquette in rear by a vertical line.



The banquette has a slope in rear.

Mark the extent of the base of this slope, upon the terreplein, by a point.



Draw THE SLOPE OF THE BANQUETTE.



Those lines in your figure, which represent the base or height of any slope, are all imaginary lines, which in a finished section would either be rubbed out or dotted.

Part of the terreplein, and of the interior slope of the parapet, also become imaginary lines, in a section, after the banquette is drawn.

Rub out all the imaginary lines in your present figure, excepting the ground line, which is necessary for our further operations.



Here it may be observed, that in drawing sections or plans of works of fortification, it is seldom usual to rub out any of the imaginary lines, which are useful in the construction, until the whole of the outline is finished in pencil.

In this book a different system is followed, a part of the

imaginary lines being generally rubbed out, before the whole of any proposed figure is completed. This has been done for the sake of clearness.

I before stated that the top of the interior slope of the parapet, which is the highest ridge of it, is called THE INTERIOR CREST OF THE PARAPET.

In like manner, the top of the exterior slope of the parapet, is called THE EXTERIOR CREST OF THE PARAPET.

A parapet therefore has two crests or ridges.

But whenever the term "crest of a parapet" is used without particularly specifying which of the two, the interior crest of the parapet is always to be understood, as may be inferred from what was before observed; it being the highest and most conspicuous ridge.

The outside or front of the rampart is called THE SCARP.

The scarp may either be REVETED or not.

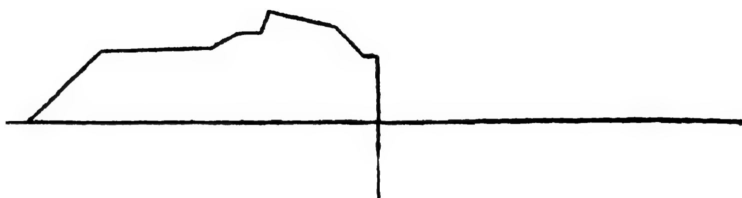
When the scarp is said to be reveted, it implies that it is faced with masonry or brickwork; and the wall, which is built for that purpose, is called THE SCARP REVETMENT.

Between the foot of the exterior slope of the parapet and the front of the revetment, a small margin or level space is generally left, which is called a berm.

Draw a horizontal line outwards to represent THE BERM.

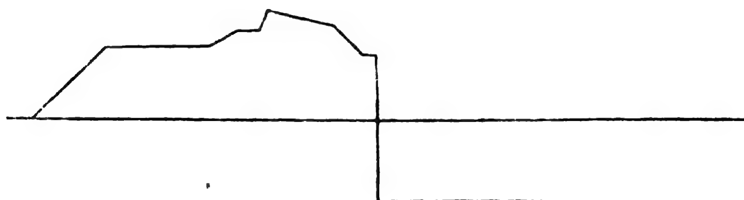


From the extremity of the berm, drop a perpendicular, intersecting the ground line, in order to represent the height of the scarp revetment.



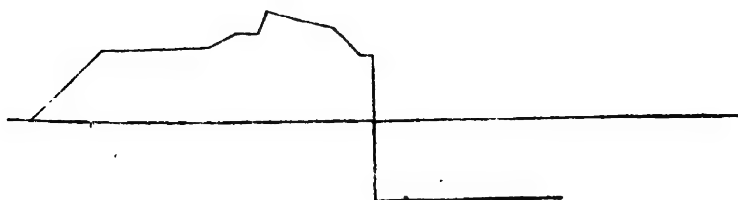
This being the principal perpendicular in the scarp, is called THE SCARP LINE. It is supposed to terminate on the same level with the bottom of the ditch.

Draw a horizontal line, outwards, from the foot of the scarp revetment, to represent the level of the ditch.

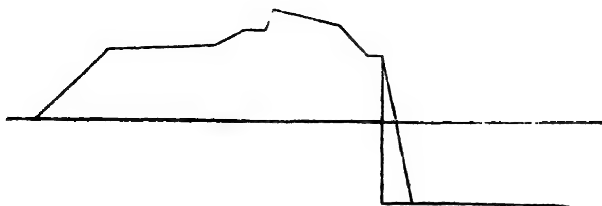


The scarp revetment has a slope.

Mark the extent of the base of this slope upon the last drawn horizontal line.

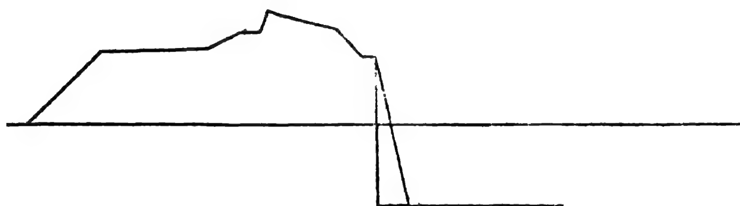


Draw THE SLOPE OF THE SCARP REVETMENT.

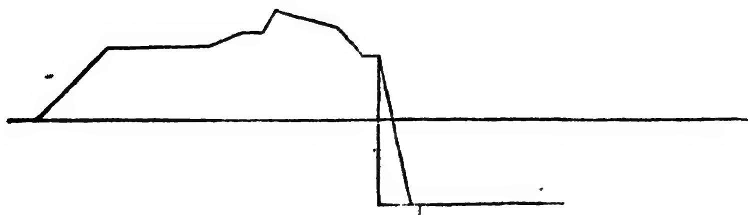


The scarp revetment has an offset as its foundation.

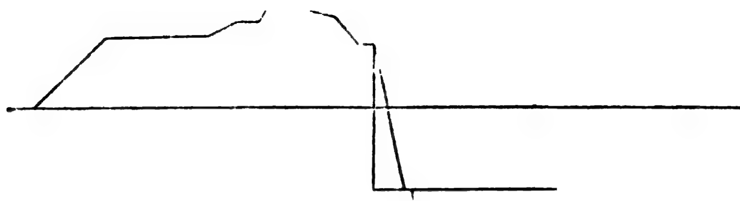
Mark THE OFFSET.



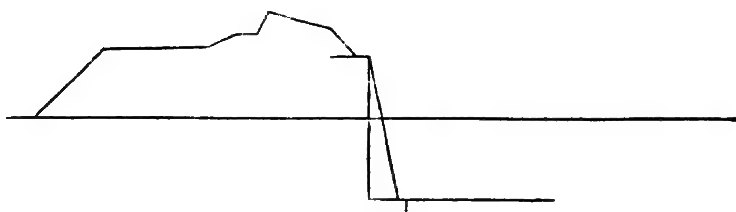
Draw a line to shew the depth of THE FOUNDATION OF THE SCARP REVETMENT, by dropping a perpendicular from the extremity of the offset.



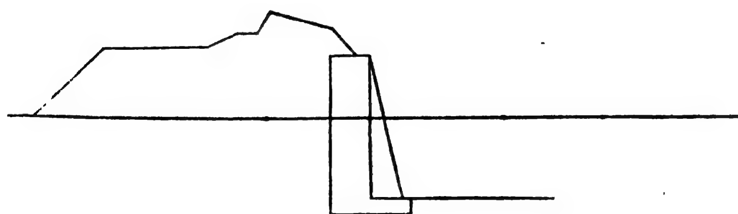
Draw a horizontal line to represent the bottom of the foundation.



Draw also a horizontal line to represent the top of the scarp revetment, part of which will agree with the berm.



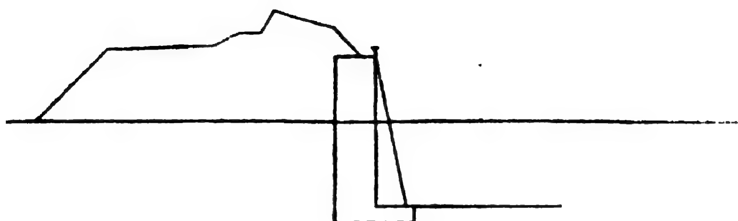
Draw a vertical line to represent the back of the scarp revetment.



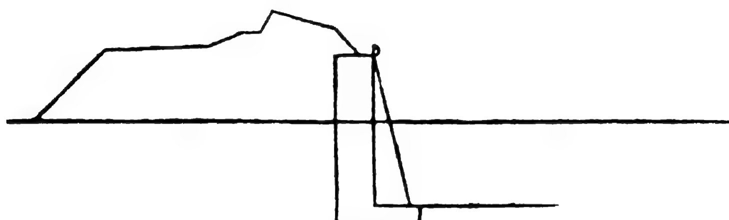
The scarp revetment usually has A CORDON.

The cordon is an upper course of cut stone, projecting a little beyond the rest of the wall, in a semicircular form.

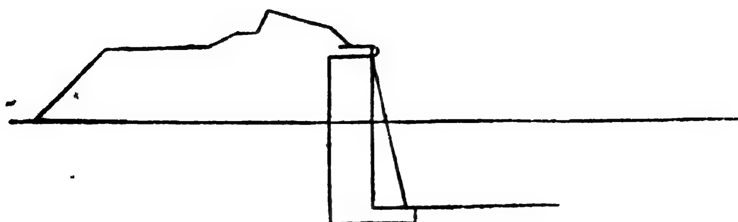
Mark the height of the cordon, upon the scarp line produced upwards.



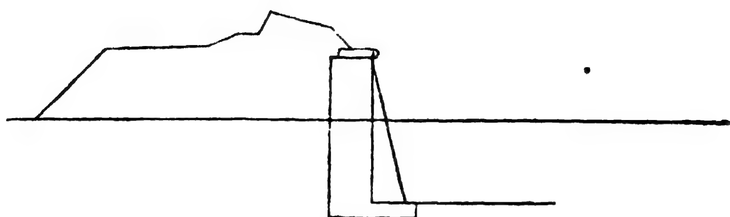
Draw the front of the cordon, by describing a semicircle upon the above produced line.



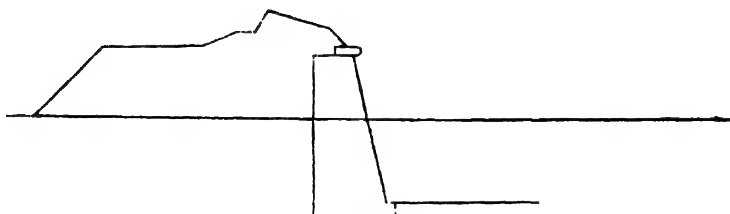
Draw the top of the cordon: and rub out the lower part of the exterior slope of the parapet, if it interferes with the cordon.



Draw the back of the cordon, which we shall suppose not to extend quite so far as the back of the revetment.



Rub out the imaginary lines in your cordon and scarp revetment.

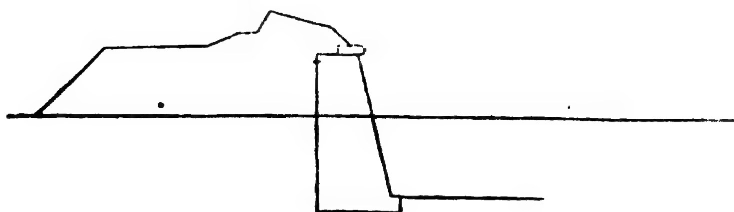


It is to be observed, that that course of masonry which forms the cordon, is not always built in the manner represented in your present figure, but is often made to extend as far back as the rest of the revetment, and the latter is of course the strongest method.

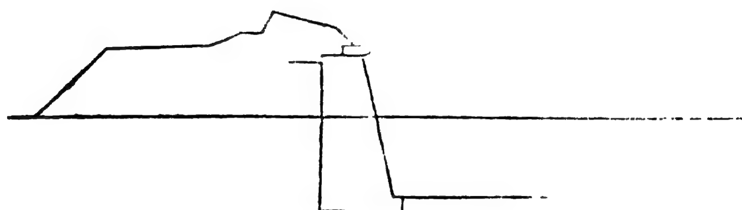
At the back of the revetment, there are generally COUNTERFORTS OR BUTTRESSES to strengthen it, built at certain intervals from each other.

The counterforts are not always made quite so high as the revetment.

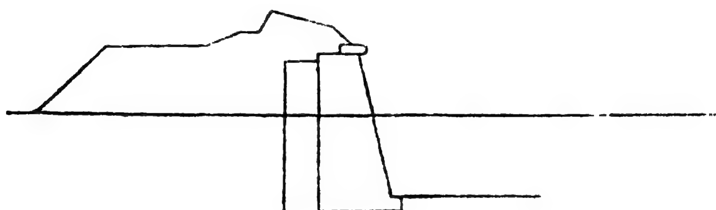
Mark a point upon the back of the revetment, a little lower than the top of it, to shew the height of the counterfort.



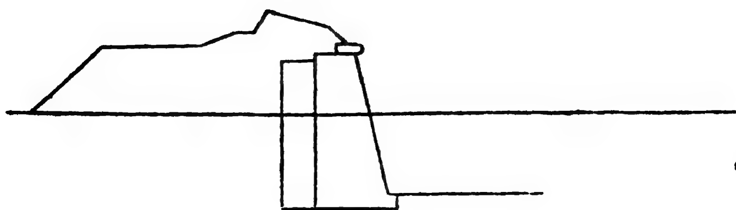
Draw the top of the counterfort.



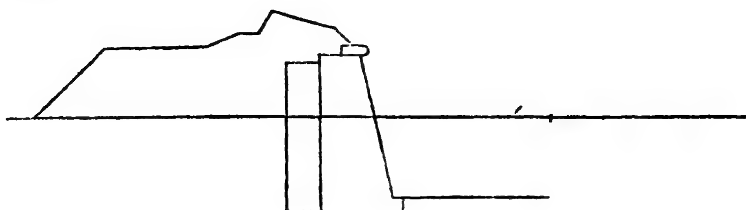
Draw the back of the counterfort.



Draw the bottom of the counterfort, by producing, backwards, the bottom of the foundation of the revetment.

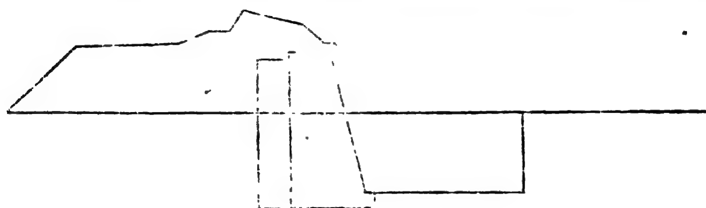


Mark a point on your ground line to shew the breadth of the ditch.



It was before explained that the interior side of the ditch, in fortification, is called the scarp; and that the exterior side of it is called the counterscarp.

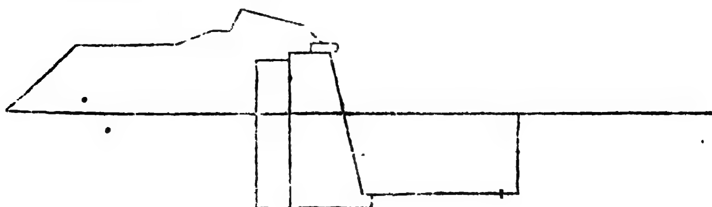
Represent the height of the counterscarp by dropping a perpendicular, from the point last marked, to meet the bottom of the ditch.



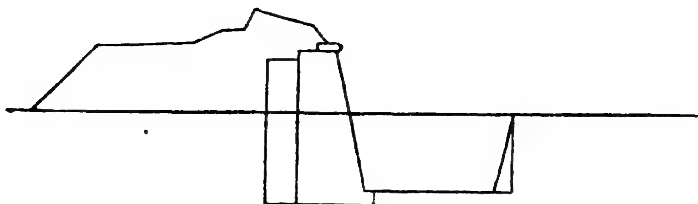
This perpendicular in the section, agrees with the counterscarp line in the plan of a fortress.

The counterscarp has also a revetment, similar to the scarp revetment, which you have just drawn.

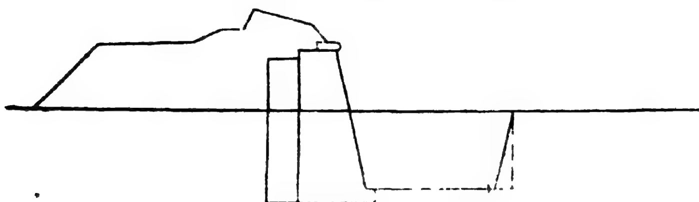
Mark the extent of the base of the slope of THE COUNTERSCARP REVETMENT by a point.



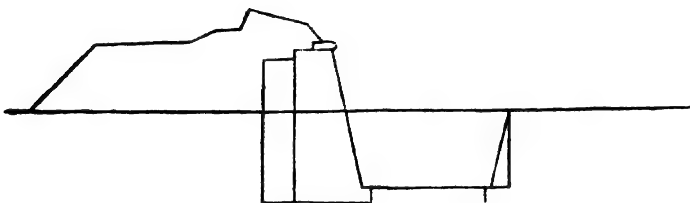
Draw the slope of the counterscarp revetment.



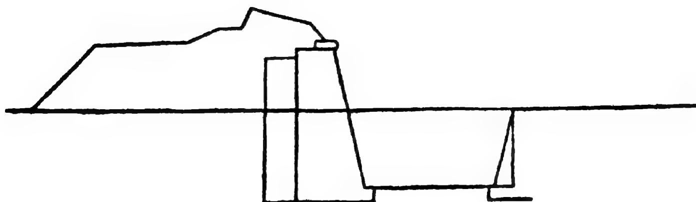
Mark the offset of the counterscarp revetment.



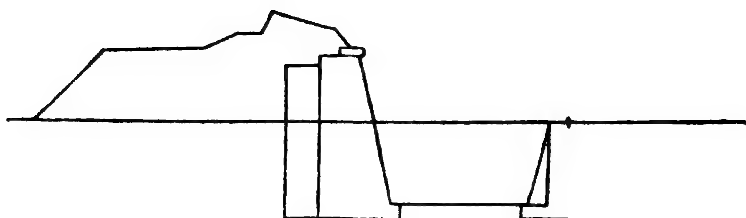
Draw a line to show the depth of the foundation of the counterscarp revetment.



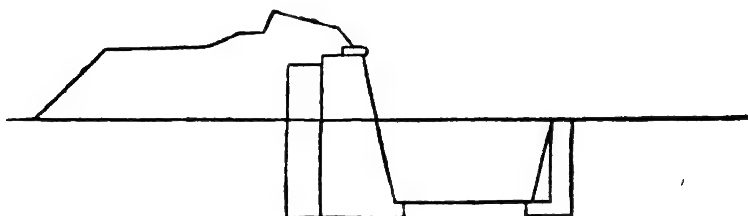
Draw the bottom of the foundation of the counterscarp revetment.



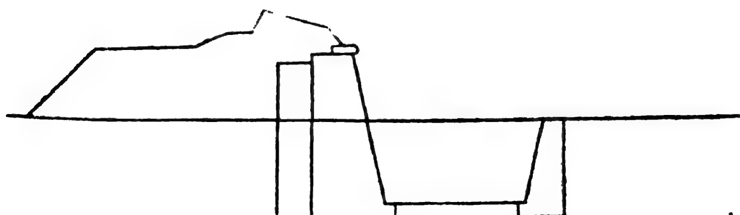
Mark the thickness of the counterscarp revetment at top.



Draw the back of the counterscarp revetment.



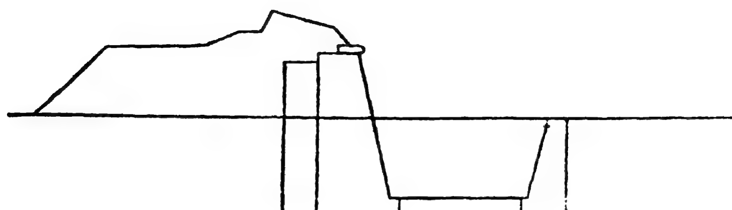
Rub out superfluous lines in your counterscarp revetment.



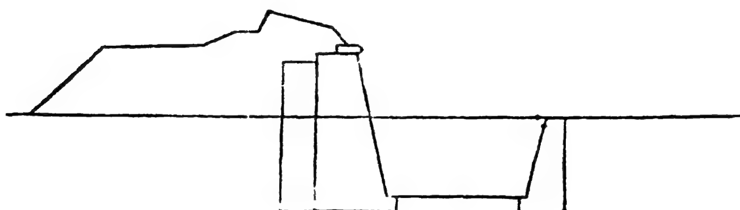
The counterscarp revetment usually has a coping, or upper course of cut stone projecting a little beyond the rest of the wall.

THE COPING OF THE COUNTERSCARP projects or overhangs about six inches in a rectangular form.

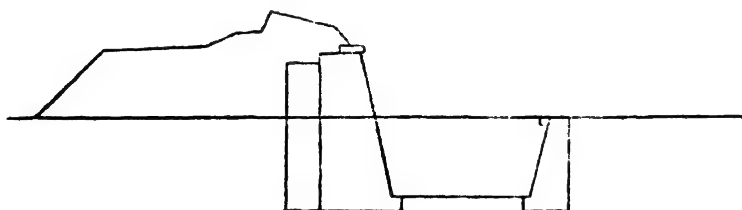
Mark the height of the coping upon the slope of the counter-scarp revetment, a little below the ground line.



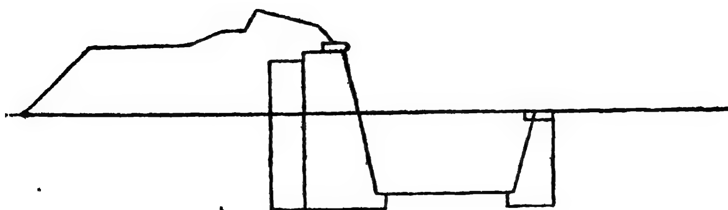
Mark the projection of the coping on the ground line.



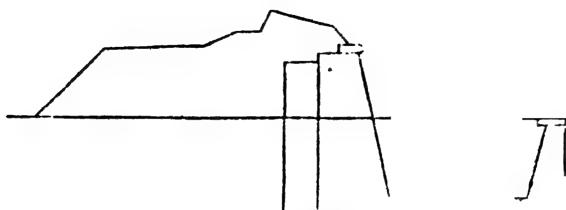
Draw the projection of the coping.



Draw the bottom of the coping.

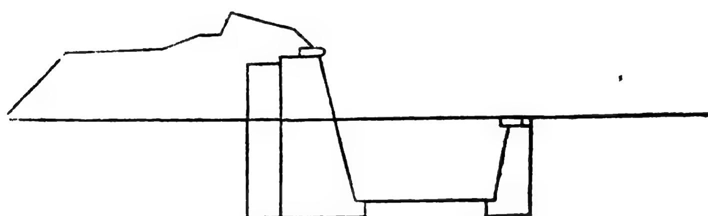


Rub out that part of your original counterscarp revetment, which becomes superfluous after the coping is drawn.

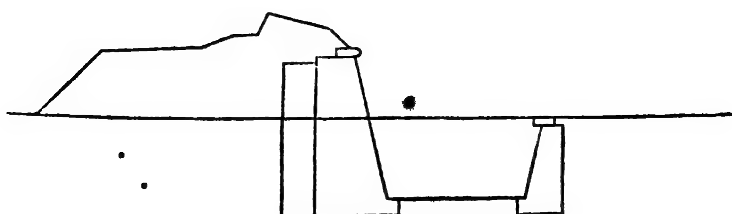


Sometimes the coping does not extend the whole breadth of the revetment. Let us suppose this to be the case in the present instance.

Draw the back of the new coping at a little distance from the back of the revetment.



Rub out that part of the revetment, which now becomes superfluous.



The counterscarp revetment may be strengthened by counterforts or buttresses, which are similar to those of the scarp.

Draw a rectangle to represent a COUNTERFORT OF THE COUNTERSCARP, making the top of it a little lower than that of the revetment, which it is intended to strengthen.

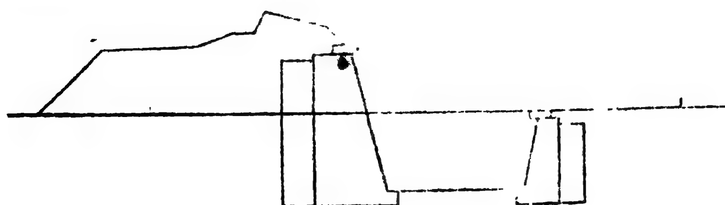


Mark the breadth of your covered way upon the ground line, by a point.

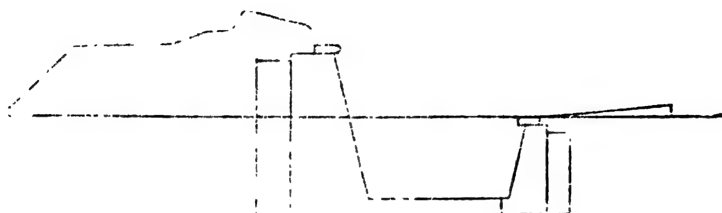


The covered way usually has a gentle slope from front to rear to carry off rain water.

From the point, which shows the extent of your covered way, raise a short perpendicular to represent the height of the said slope.

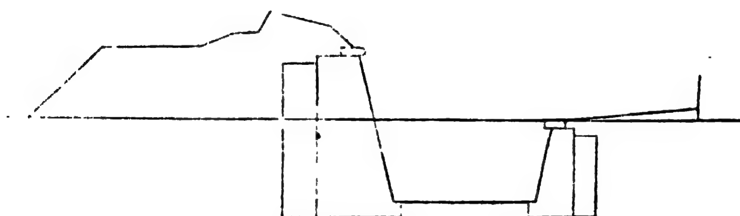


Draw THE SLOPE OF THE COVERED WAY, and raise the top of the coping a little, so as to agree with the slope.

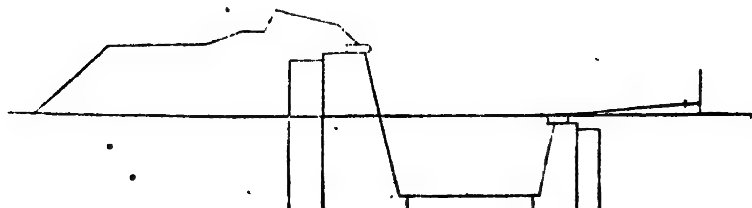


In front of the covered way is the glacis, the back of which, being raised to a certain height, serves as a parapet for the covered way.

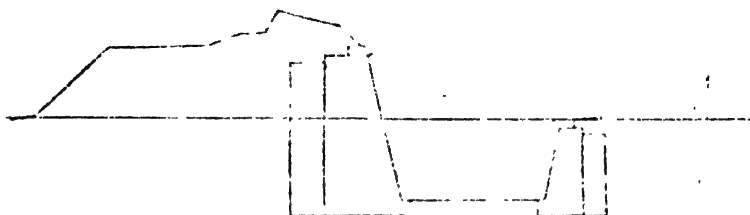
Represent the height of THE PARAPET OF THE COVERED WAY by a vertical line.



Mark a point upon the covered way, to show the extent of the base of the interior slope of the parapet.



Draw the interior slope of the parapet of the covered way.



The crest of the parapet of the covered way is also called THE CREST OF THE GLACIS; and this latter term is commonly used in preference to the former.

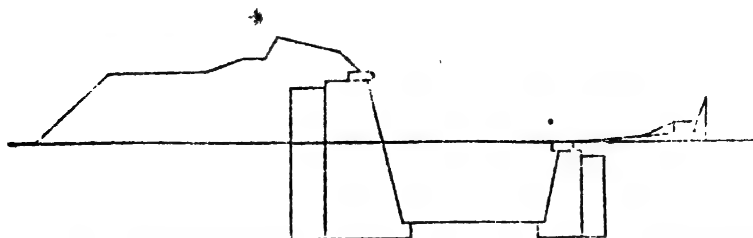
The parapet of the covered way has a banquette in rear of it, similar to that of the rampart.

Mark the level of the banquette of the covered way.

Draw the tread of the banquette.

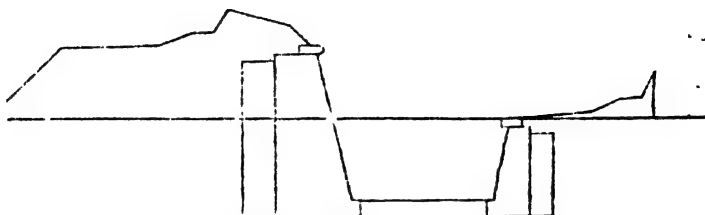
Represent its height in rear by a vertical line.

And draw its slope; all of which operations must be performed in the same manner that was before described, in treating of the former banquette.

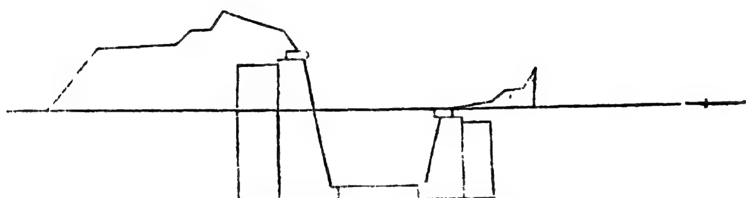


THE BANQUETTE OF THE COVERED WAY is now complete.

Rub out all the imaginary lines of the parapet and banquette of the covered way; leaving only that perpendicular, which shows the height of the crest of the glacis.

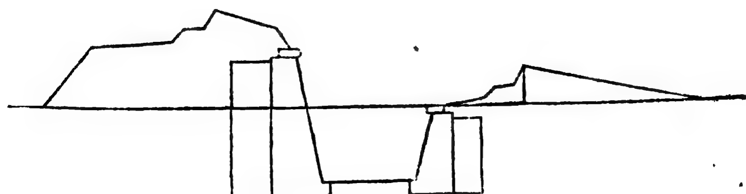


Mark the breadth of the glacis upon your ground line; measuring from the foot of the above perpendicular, outwards.*



This distance shows the extent of the slope of the glacis, which is continued regularly from the crest outwards, until it meets the natural level of the ground.

Draw THE SLOPE OF THE GLACIS.



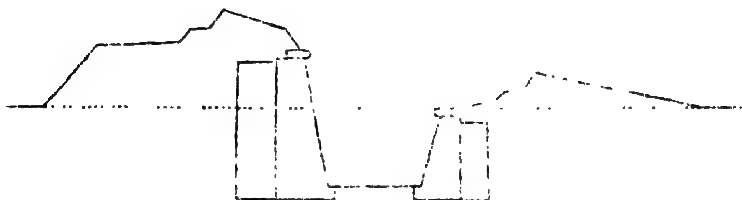
* The following figures are done on a smaller scale than the former ones, in order not to exceed the width of the page.

The point, where the slope of the glacis terminates, is called THE FOOT OF THE GLACIS.

All that part of the ground line, which is comprehended between the bottom of the interior slope of the rampart, and the foot of the glacis, now becomes an imaginary line; and must either be rubbed out, or dotted, in a finished section.

Dot the above-mentioned part of your ground line:

And rub out that line, which represents the perpendicular height of the crest of your glacis.



Rub out your dotted line.

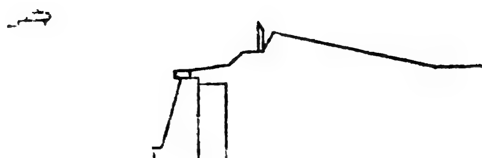
On the front of the banquette of the covered way, there is a row of palisades planted.



Palisades are strong wooden stakes, driven into the ground vertically or nearly so, a few inches apart. They are generally made of oak, or hard wood, seldom less than 6 inches thick, and of such a height as to form an obstacle to troops. The palisades of the covered way are either made of the same height as the crest of the glacis, or a little higher.

DRAW THE PALISADE OF THE COVERED WAY, representing

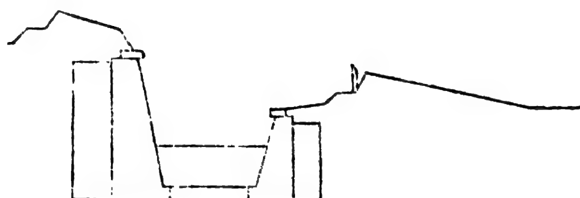
the thickness of it by two parallel vertical lines, except at top, where it must be pointed.



The ditch, in its present form, represents A DRY DITCH.

Sometimes the ditch may be wet, or partly filled with water.

Draw a horizontal line to represent the surface of water in A WET DITCH.



You will have observed, that the covered way is nearly on the same level as the original ground, on which the fortress is supposed to be constructed: but that the ditch is sunk below this level; whilst the rampart and glacis are raised above it.

In planning a fortress, it therefore becomes a matter of importance, to make the ditches of such dimensions, that the rubbish, excavated from thence, may just be sufficient for forming the elevated parts of the rampart and glacis.

If this rule is not attended to, it may be necessary, either to bring a considerable part of the materials for finishing the ramparts

and glacis from a great distance; or to cart away the superfluous rubbish from the ditches into the country, instead of being able to use it on the spot: in either of which cases a needless loss of time, labour, and expense will be incurred.

Sometimes instead of a semicircular cordon for the scarp revetment, a simple coping is used like that of the counterscarp. Sometimes both cordon and coping are dispensed with. Sometimes also the counterscarp revetment is not continued quite so high as the level of the covered way.

There may also be several other variations in the profile of a fortified place, which shall be noticed hereafter.

CHAP. IV.

OF THE USUAL MODE OF CONSTRUCTING THE OUTLINE OF THE PLAN OF A REGULAR FORTRESS.—COUNTERFORTS AND TRAVERSES FURTHER EXPLAINED.

In drawing the outline of the plan of a regular fortress, the first thing necessary is to describe a regular polygon, inclosing the town or spot of ground which is to be fortified.

The nature of THE POLYGON will depend upon the size or extent of the place or position, that is to be fortified. For instance, a small town may be fortified by a hexagon or figure of six sides; whereas a large town or city may require a decagon or figure of ten sides, or even more.

The smallest regular work in use is a square fort.

The next to this is a pentagon.

The square and pentagon are used only for citadels, or for the defence of posts of secondary importance.

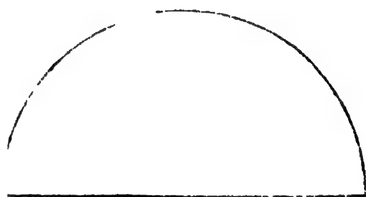
After the polygon is described, all regular fortresses are constructed nearly in the same manner, each front of the fortress being made to correspond with a side of the polygon.

Let us suppose that the fortress to be represented is a regular hexagon. If we construct a half hexagon, it will explain the matter equally well.

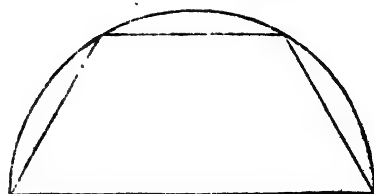
Take a half sheet of large paper, and turn one of the long sides of the paper towards you.

Draw a right line across your paper near the bottom of it.

Upon this line, with a radius rather less than one third of the breadth of the paper, describe a semicircle, the center of which must agree with the middle of the paper.



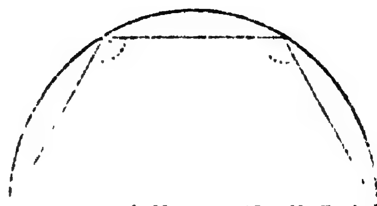
In this semicircle describe a half hexagon, to represent part of the polygon that you propose to fortify.



The three sides of the half hexagon are called THE EXTERIOR SIDES OF THE POLYGON.

The angles, formed by the exterior sides, are called EXTERIOR ANGLES OF THE POLYGON.

Mark the exterior angles of the polygon, that are shown in your present figure.



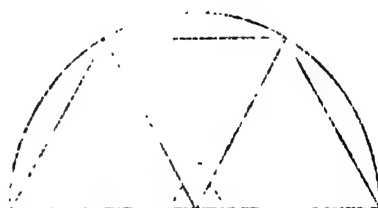
Rub out your marks.

From the center of your half hexagon, draw radii to the two exterior angles of the polygon, which are shown in your figure.



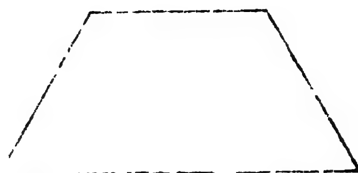
The angle, formed by any two adjoining radii, is called an interior angle of the polygon.

Mark THE INTERIOR ANGLES OF THE POLYGON, represented in your present figure.



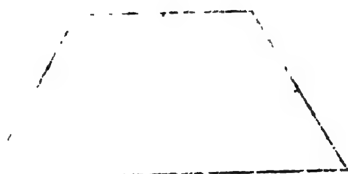
The interior angles are also sometimes called THE ANGLES AT THE CENTER OF THE POLYGON.

Rub out the semicircumference, the two last drawn radii, and the marks of the interior angles of your polygon. The half hexagon, and diameter only will remain.

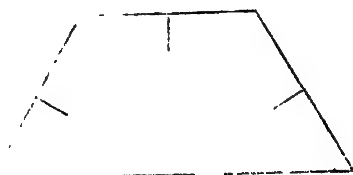


We shall now proceed with the construction.

Bisect each of the exterior sides of your polygon.



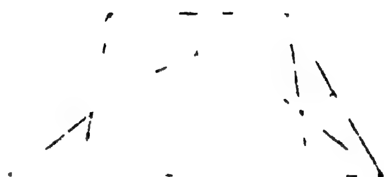
From the middle of each exterior side, drop perpendiculars, inwards, of a given length; for instance let these perpendiculars be one sixth of the exterior sides.



On examining the figure, it will be found that the perpendiculars are more than one sixth of the exterior side, notwithstanding the above direction. The same deviation from the rules given in the text will be found in some other parts of this book. The reason is, that the figures, in general, being on a very small scale, the various parts represented would not be sufficiently clear, if the whole of them were always drawn according to their just proportions. But wherever there is any variation of this nature, the learner is recommended to follow the directions contained in the text, making his figures as much larger than those in the book, as he may find convenient.

When "THE PERPENDICULARS," are mentioned, in describing a system of fortification, it always implies the lines which you have just drawn, unless any thing to the contrary is specified; because although there may be many other lines perpendicular to each other, in the plan of a fortress, these are the principal perpendiculars, and of most use in the construction.

From the adjoining exterior angles of the polygon, draw lines intersecting each other at the foot of the perpendiculars.



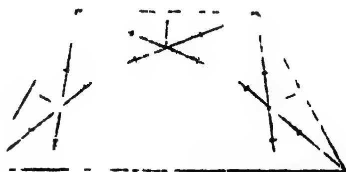
These lines are called THE LINES OF DEFENCE.

The salient angles, formed by these last drawn lines, correspond with the salient angles of THE BASTIONS of your fortress.

Upon the lines of defence, measure a certain distance from the salient angles on each side; and mark points for the shoulders of your bastions. For instance, let the distance set off be about one third of your exterior sides.



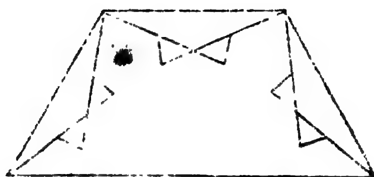
Take in your compasses the distance between the salient angle of one bastion, and the shoulder of an adjoining one; and from each of the salient angles as a center, with the above radius, make intersections upon those lines of defence which are drawn from the same point.



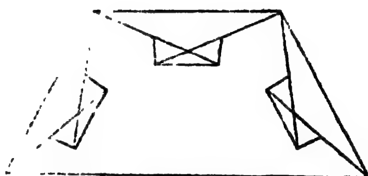
The points last marked will show the position of the angles of the flank.

By joining the various points in the lines of defence, you will have the flanks of your bastions and the curtains.

Draw THE FLANKS.



Draw THE CURTAINS.

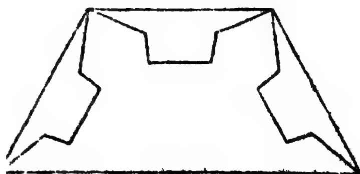


The lines of defence, properly speaking, extend only from the angles of the flank of any bastion to the salient angles of the adjoining bastions.

The body of the place of your half hexagon is now complete. It consists of three fronts of fortification; each front, as was before observed, being composed of two demibastions and one curtain.

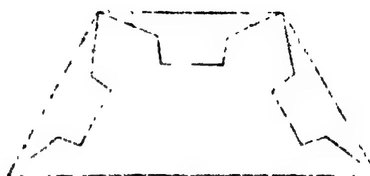
Rub out your perpendiculars.

Rub out also those parts of your lines of defence, which will become imaginary lines, after the bastions are drawn.



The angles, comprehended between the exterior sides of the polygon, and the faces of the bastions, are called THE DIMINISHED ANGLES OF THE POLYGON.

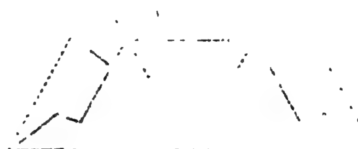
Mark the diminished angles of your polygon.



Rub out the marks of the diminished angles; and dot the exterior sides of your polygon.

Draw the capitals of your bastions; and dot them. They will of course agree with part of the radii of the polygon, which you before drew.

Represent the demigorges of your bastions by producing the curtains, till they meet the capitals on each side of them: and let the demigorges also be dotted.



The right line, which is composed of one curtain and two adjoining demigorges, is called an interior side of the polygon.

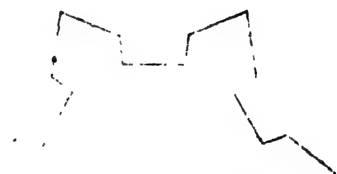
There are three of these lines in your present figure; and they are called THE INTERIOR SIDES OF THE POLYGON, because if you examine attentively, you will observe that they form a regular half hexagon, or figure exactly similar to that which is formed by the exterior sides.

When the exterior sides of the polygon are first drawn, in the

manner, that we have followed in the above construction; this is called FORTIFYING INWARDS; because the whole of the body of the place comes within the original polygon.

But when the interior sides of the polygon are first drawn in any plan, and the other lines are marked off afterwards; it is called FORTIFYING OUTWARDS; because in this case, the body of the place comes without your original polygon.

Rub out all imaginary lines, that is to say all the dotted lines in your plan.



The remaining lines (not including of course the diameter of your original semicircle) will represent THE OUTLINE OF THE BODY OF THE PLACE of a regular half hexagon.

This is called THE MASTER LINE OF THE FORTRESS; and it corresponds with THE SCARP LINE, in the profile or section, which was before explained.



Sometimes it is also called THE CORDON LINE, because it agrees nearly with the front of the cordon of the scarp revetment.

We shall next proceed to draw the main ditch of our fortress.

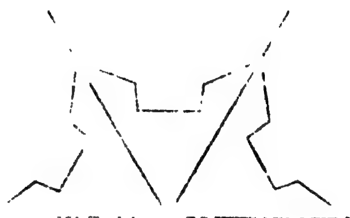
The number of fronts in the book will now be reduced from three to one, which will be drawn on a larger scale, in order that the remaining figures may not appear too complicated.

But the Teacher may, if he thinks proper, cause the Learners to continue to construct their figures with three fronts; and without changing their scale.

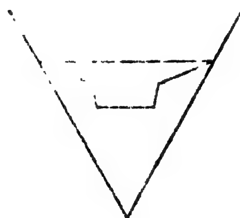
In that case, he will make them pass over a part of the succeeding paragraphs, until the body of the place of the new figure consisting only of one front is supposed to be constructed; proceeding at once to that paragraph in page 51, which commences thus, " The main ditch, or ditch of the body of the place," *&c.*

If the Teacher should however think it expedient to make the Learners construct one front on a large scale, before they draw a complete half hexagon; he may then, instead of omitting any part of the succeeding paragraphs, go on with the whole of them in regular order, as follows.

Draw two radii to divide the center front of your half hexagon, from the two other fronts.



Rub out your two extreme fronts, leaving only the center front, with the radii which bound it.



Your figure in its present state represents one front only of a hexagon; but as the several fronts of a regular fortress are exactly alike; if you know how to construct one, it will be a sufficient rule for all the others.

We will, therefore, construct one complete front only of a regular fortress, previously rubbing out our present figure, and commencing another, on a larger scale, for the sake of clearness.

Draw a right line to represent the exterior side of one front of your new figure, on a larger scale.



We shall next draw a part of the two radii of the proposed front: it being unnecessary to draw the whole of them.

Divide your exterior side into three equal parts.



The angle formed by the exterior side of a hexagon, and either of its radii, is equal to the angle formed by any two sides of an equilateral triangle.

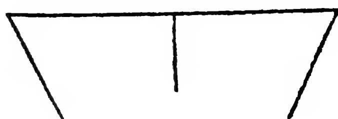
In order to find a part of the radii of your proposed front, you will therefore construct an equilateral triangle, on the two extreme parts, that is to say, on the first and third divisions, of your exterior side.



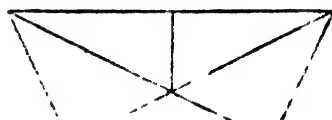
Rub out those two opposite sides of your equilateral triangles, which are nearest to the middle of the exterior side.



Your figure, in its present state, represents the exterior side of one front of the polygon, and a part of two radii, such as were shown in one of your former figures, but on a larger scale.



Bisect your exterior side, according to the rule before explained: drop a perpendicular from the middle of it; and make the perpendicular equal to one sixth of the exterior side.

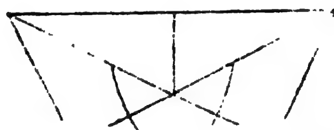


From the extremities of your exterior side, draw the lines of defence, intersecting each other at the foot of the perpendicular.



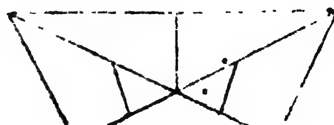
From the extremities of your exterior side, which represent the positions of the salient angles of two bastions, mark a given distance on the lines of defence; for instance, a distance equal to one third of the exterior side.

The points last marked will represent the shoulders of the bastions.



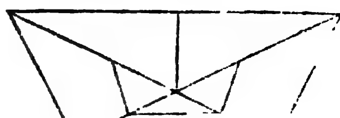
You will next take in your compasses the distance between the salient angle of one bastion, and the shoulder of the other, and from each of the salient angles, as a center, with the above radius, make an intersection upon that line of defence, which is drawn from the same point.

The new points thus found will show the angles of the flank, as was before explained.



Draw your flanks.

Draw your curtains.



The body of the place of one front, is now complete, on a larger scale than before.

We shall next proceed to draw the main ditch.

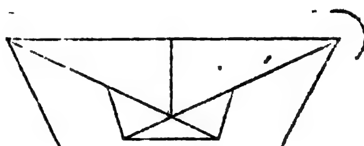
The following directions apply either to the finishing of the outline of one front of fortification, such as is represented in your present figure; or to several, as for instance, to a figure with three fronts, such as the outline of the half hexagon, which you before drew.

The main ditch, or ditch of the body of the place, is bounded by the scarp and counterscarp.

The scarp line has just been drawn: it remains to draw the counterscarp.

The counterscarp is made circular, opposite to the salient angles of the bastions.

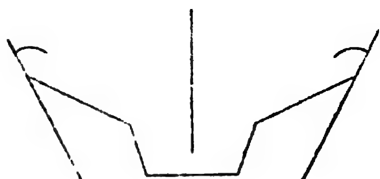
From each salient angle as a center, with a given radius, as for instance, one half of your perpendicular, describe arcs outwards towards the country.



If the learners are continuing their former half hexagon:

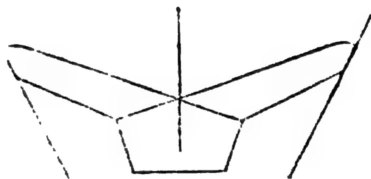
Restore your original perpendiculars in each front, and produce them outwards.

If the learners are drawing one front only, according to the figures immediately preceding:

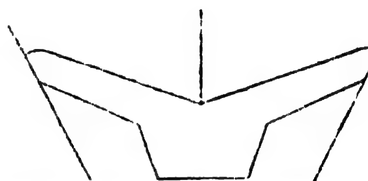


Rub out all imaginary lines except your perpendicular, and your two radii, which you will produce outwards.

The straight parts of your counterscarp, which commence where these circular parts finish, are generally directed towards the shoulders of the nearest bastions.

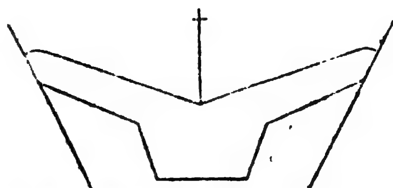


From the shoulders of every bastion, draw tangents to the above arcs.



Rub out the superfluous parts of the arcs, and of the counterscarp lines; that is to say those parts of the last drawn lines, which are between the shoulders of the bastions, and the point of intersection of these lines.

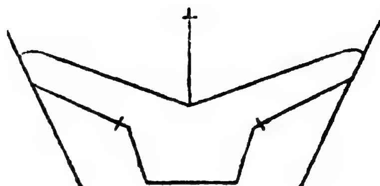
The form of THE COUNTERSCARP OF THE BODY OF THE PLACE is now complete; as also that of THE MAIN DITCH.



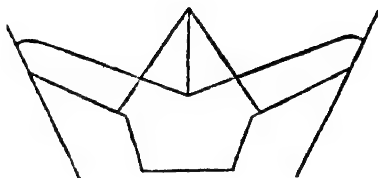
Upon each perpendicular produced, mark a point at a given distance from the reentering angle of the counterscarp. Let this distance, for instance, be equal to the faces of your bastions.

The points just marked, show the position of the salient angles of THE RAVELINS.

Upon each of the faces of your bastions, mark a point near the shoulder, at a given distance.

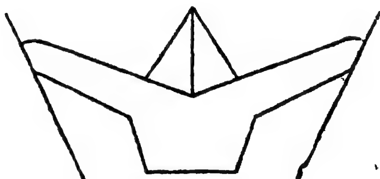


Draw right lines, from the points marked on each produced perpendicular, to those which are marked on the faces of the bastions of the same fronts.



Rub out the superfluous parts of your last drawn lines, that is to say, those parts of them which cross the main ditch.

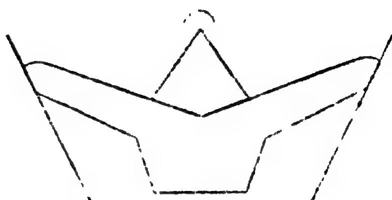
The faces of your ravelins will then be complete.



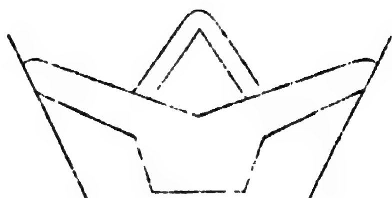
Rub out the capitals of your ravelins.

The ravelins have ditches and counterscarps.

That part of THE COUNTERSCARP OF THE RAVELIN, which is immediately in front of the salient angle, is made circular.

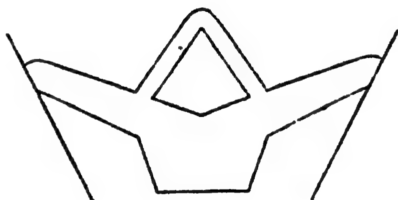


From the salient angle of each ravelin, as a center, with a given distance as a radius, for instance, about two thirds of the width of the main ditch, measured at the salient angles of the bastions, describe an arc outwards.

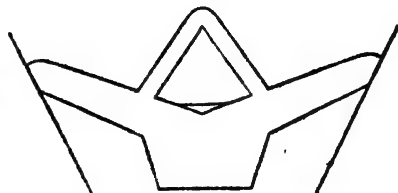


Draw tangents to each arc, parallel to the faces of the ravelins, and produce them till they meet the counterscarp of the body of the place.

The main ditch and THE DITCHES OF THE RAVELINS communicate with each other.

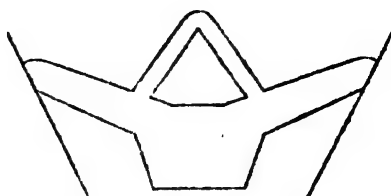


Rub out therefore the superfluous parts of your original counterscarp, as also of the last described arcs.



Draw the break at the gorge of the ravelin, in every front.

Rub out those parts of the demigorges of your ravelins, which become superfluous, after the breaks are drawn.



The outline of the counterscarp of a regular half hexagon
front of fortification.

with ravelins
a ravelin is now complete.

The covered way is bounded by the counterscarp and glacis.

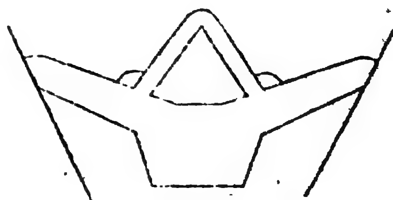
That side of the glacis, which is next to the covered way, is called the crest of the glacis, as was before explained in treating of the profile of a regular fortress.

The crest of the glacis is drawn parallel to all the faces of the counterscarp, at a given distance; but these parallels are produced till they form salient angles without being rounded off like the salients of the counterscarp.

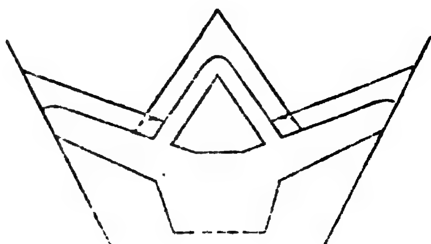
Let us suppose that the breadth of the covered way is to be about one third of the breadth of the main ditch.

The most convenient mode of drawing the crest of the glacis, is first to describe arcs, at a given distance from all the reentering angles of the counterscarp.

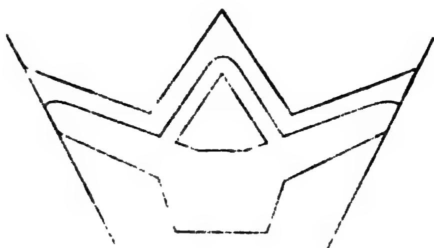
You will therefore, from each reentering angle of your counterscarp as a center, with a radius equal to one third of the breadth of the main ditch, describe arcs to show the extent of the covered way.



Draw tangents to these arcs parallel to all the faces of the counterscarp.



Rub out your arcs, and the superfluous parts of your tangents.



Any part of the covered way, which is more spacious than the rest of it, is called a place of arms.

Those parts of the covered way, which are in front of the salient angles of the bastions and ravelins, being more spacious than the rest of it, are therefore places of arms, and from their position they are called THE SALIENT PLACES OF ARMS OF THE COVERED WAY.

Here the Teacher will cause the Learners to " mark the salient places of arms of the covered way;" *and afterwards to* " rub out the marks."

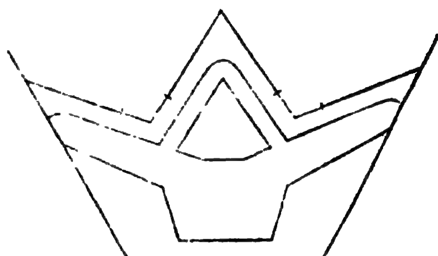
There are also reentering places of arms, that is to say, spacious parts near the reentering angles of the covered way. These are not yet drawn.

The reentering places of arms have two demigorges and two faces.

The demigorges are marked by setting off a given distance upon the crest of the glacis, on each side of the reentering angles.

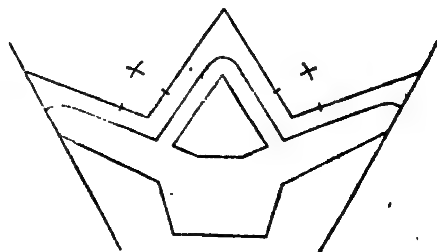
Let us suppose the length of the demigorges to be equal to the breadth of the main ditch nearly.

You will accordingly mark the demigorges of the reentering places of arms of the covered way, at the above distance, on each side of the reentering angles of the covered way.

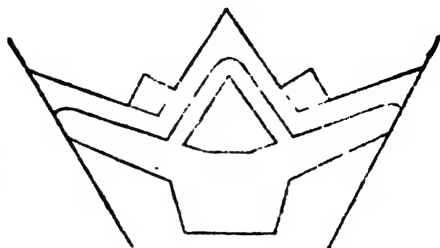


Take in your compasses a distance a little longer than one of the demigorges, for instance, about one tenth longer; and let this represent the length of the faces of your reentering places of arms.

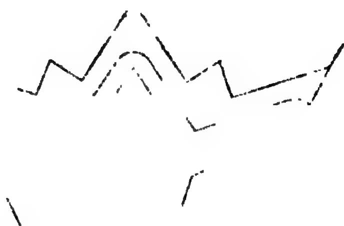
With this distance as a radius, from the extremities of each pair of demigorges as centers, describe arcs intersecting each other towards the country.



The points of intersection, thus found, show the position of the salient angles formed by the faces of the reentering places of arms.



From each of the above points of intersection, you will therefore draw right lines to the extremities of the demigorges. This being done, rub out the small arcs, which will then become superfluous.



Rub out also those parts of the original crest of your glacis, which will become superfluous, after THE RE-ENTERING PLACES OF ARMS OF THE COVERED WAY are drawn. Rub out also the superfluous parts of the faces of the said reentering places of arms; namely that part of each face which crosses the covered way.

The long faces of the covered way are called branches; and take their names from the work immediately behind them.

For instance, there are two branches of the covered way, in front of every bastion of a regular fortress.

One of these is called THE RIGHT BRANCH OF THE COVERED WAY OF THE BASTION.

The other is called THE LEFT BRANCH OF THE COVERED WAY OF THE BASTION.

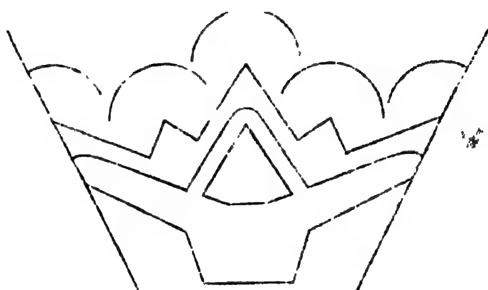
There are also two branches of the covered way in front of every ravelin of a regular fortress.

One of these is called THE RIGHT BRANCH OF THE COVERED WAY OF THE RAVELIN.

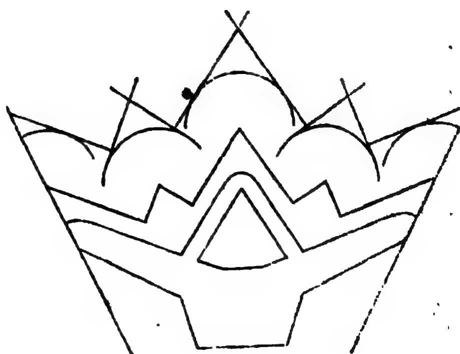
The other is called THE LEFT BRANCH OF THE COVERED WAY OF THE RAVELIN.

The foot of the glacis is drawn parallel to the crest of it. The most convenient mode of drawing it, is first to take the breadth of the glacis as a radius, and from all the salient angles of the covered way, as centers, to describe arcs.

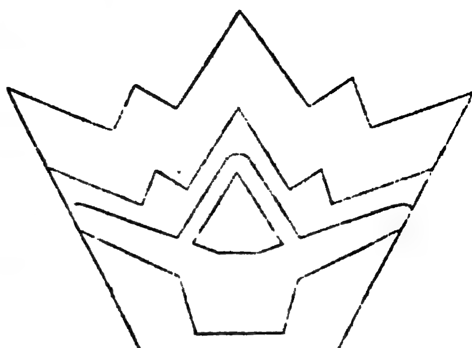
Let us suppose the breadth of the glacis to be nearly double the breadth of your main ditch. Take this distance in your compasses, as a radius, and describe arcs outwards, from all the above-mentioned salient angles.



Draw tangents to these arcs, parallel to all the faces of the covered way; or, in other words, parallel to THE CREST OF THE GLACIS.



Rub out the superfluous arcs, &c. and the exterior lines of your figure will show the form of THE FOOT OF THE GLACIS.



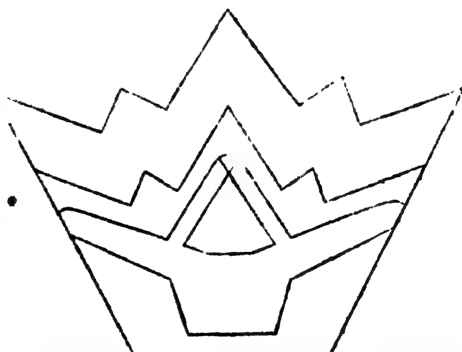
Every branch of the covered way has traverses, or small parapets extending across it, of the same height as the crest of the glacis nearly.

These traverses are intended to protect troops posted in the covered way, against raking shot from an enemy's batteries.

There are advanced traverses, and retired traverses.

I shall first explain the method of drawing the advanced traverses.

Produce the faces of all your bastions and ravelins across the ditches, until they meet the counterscarp.



If the Learners are continuing the construction of a half hexagon, the Teacher will now direct as follows.

Place one leg of your compasses in the center of the circular part of the counterscarp of a bastion, that is to say on the point where the counterscarp would be intersected by the capital of the bastion produced.

Measure the distance from this point to either of the adjoining points, marked on the counterscarp of the same bastion, by one of its faces produced.

Set off the same distance, in the same manner, upon the two circular parts of the counterscarp, in front of each of the demi-bastions at the right and left extremities of your figure.

When this is done, the Teacher will pass over such of the following directions as apply to the single front of fortification only, and will proceed to that paragraph in page 64, which commences thus: " From the various points, marked on your counterscarp, draw perpendiculars," &c.

If the Learners, however, are not drawing a half hexagon, but one front of fortification only, such as appears in this part of the book; then the Teacher will direct as follows.

The faces of the demibastions, shown in your present front of fortification, would, if produced, cross the ditches of the two adjoining fronts, to the right and left of it, no part of either of which is represented in the figure.

And in like manner, the faces of the nearest demibastions of the two adjoining fronts, would, if produced, cross the main ditch and meet the counterscarp of your present front.

It is therefore necessary, before the proper number of points

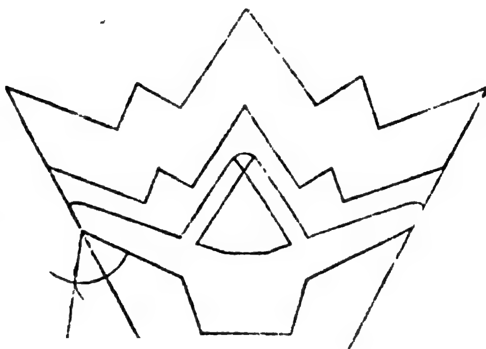
on the counterscarp of your figure can be determined, to find the position of the face of one demibastion of an adjoining front.

We shall choose, for this purpose, that front which is to the left of our figure.

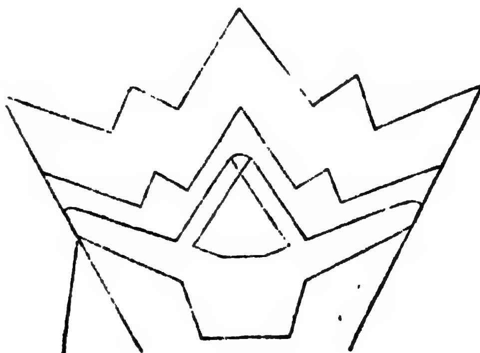
It has already been explained, that the capital of any regular bastion bisects it.

From the point of your left demibastion, you will therefore draw a right line, forming an angle on the left side of the capital, equal to that angle which is formed by the capital and the face of the said demibastion.

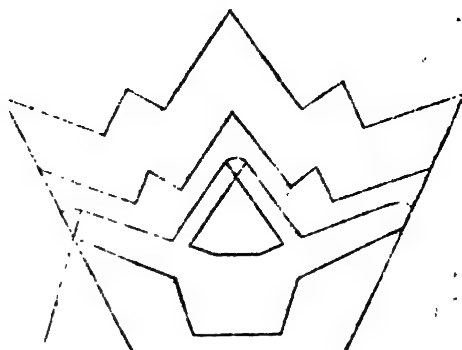
The method of performing this problem by means of intersecting arcs was explained in the Course of Practical Geometry.



Rub out the arcs, by means of which you found your new angle; and the line last drawn will show the face of an adjoining demibastion, which forms a part of the next front of our supposed fortress.

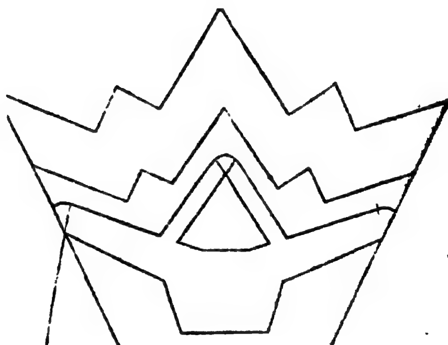


Produce the last drawn face across the ditch, till it meets the counterscarp of the left demibastion of your original front.



Place one leg of your compasses in the point, where the capital of the left demibastion of your original front cuts the counterscarp; and from thence measure the distance to the point, where the counterscarp of the same demibastion is met by the produced face of the adjoining front.

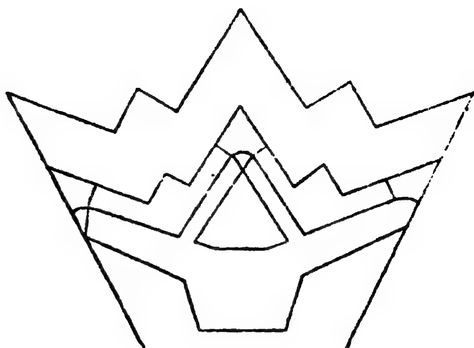
Set off the same distance, in a similar manner, upon the counterscarp of the right demibastion of your original front.



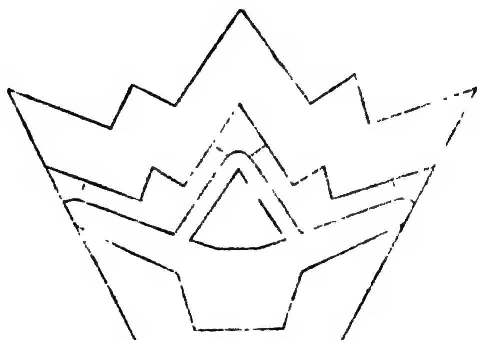
This being done, rub out the superfluous face, which is to the left of your original front of fortification.

Here the same directions will again apply, either to the half hexagon, or to a single front of fortification.

From the various points, marked on your counterscarp, draw perpendiculars across the covered way.



Rub out the lines that cross your ditches.

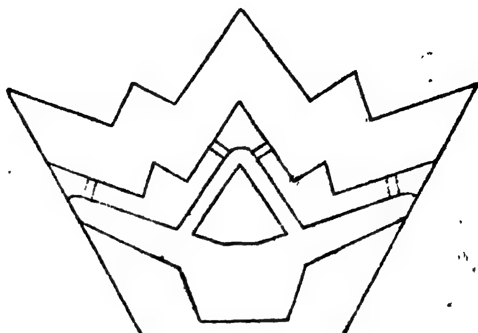


Each of the perpendiculars, drawn across your covered way, epresents the front, or outside of an advanced traverse; or in other words that side of it, which faces towards the country and would be exposed to an enemy's fire.

The back or inside of each advanced traverse is drawn parallel to the above lines at a given distance, on that side of each, which faces towards the interior of the fortress.

Let us suppose this distance to be about two thirds of the length of your traverses.

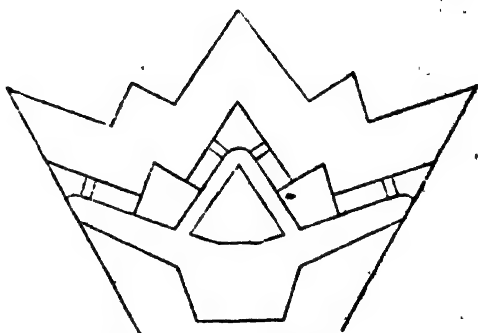
Draw the back, or inside, of each advanced traverse, accordingly.



The whole of THE ADVANCED TRAVERSES OF THE COVERED WAY are now complete.

The line, which represents the back of a traverse, is also called THE CREST OF THE TRAVERSE, because it is the highest part of it.*

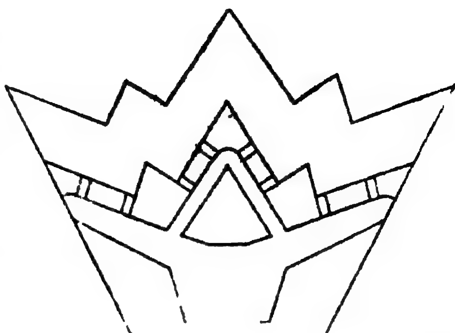
Draw perpendiculars across the covered way, from all the re-entering angles of the crest of the glacis.



These last drawn perpendiculars are to represent the back or crest of THE RETIRED TRAVERSES OF THE COVERED WAY.

* It will be understood, that the term crest of a traverse implies the interior crest of it, as was explained in treating of the parts of a parapet, to which a traverse is similar in every respect.

Draw the front of each of the retired traverses, parallel to the crest of them, at a given distance, which you may make equal to the breadth of your former traverses.



The traverses are distinguished from each other, by the particular branch of the covered way, in which they are situated

For instance, there is

THE ADVANCED TRAVERSE OF THE RIGHT BRANCH OF THE COVERED WAY OF A BASTION:

THE RETIRED TRAVERSE OF THE RIGHT BRANCH OF THE COVERED WAY OF A BASTION:

THE ADVANCED TRAVERSE OF THE LEFT BRANCH OF THE COVERED WAY OF A BASTION:

THE RETIRED TRAVERSE OF THE LEFT BRANCH OF THE COVERED WAY OF A BASTION

THE ADVANCED TRAVERSE OF THE RIGHT BRANCH OF THE COVERED WAY OF A RAVELIN

THE RETIRED TRAVERSE OF THE RIGHT BRANCH OF THE COVERED WAY OF A RAVELIN.

THE ADVANCED TRAVERSE OF THE LEFT BRANCH OF THE COVERED WAY OF A RAVELIN: and

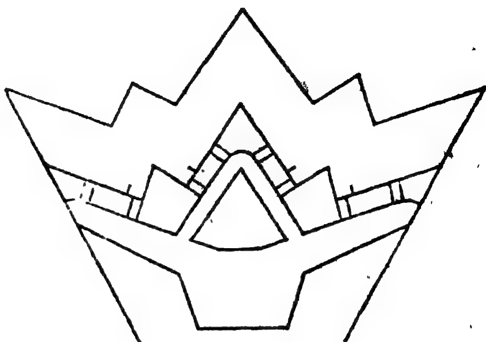
THE RETIRED TRAVERSE OF THE LEFT BRANCH OF THE COVERED WAY OF A RAVELIN.

All of which eight traverses may be distinguished in one front of fortification.

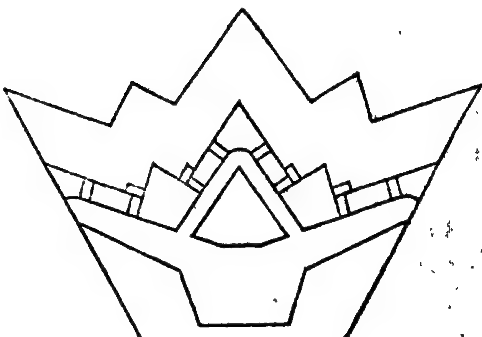
The traverses, in their present form, having blocked up the whole of the covered way; it is necessary to make passages or communications round them, at a given distance.

Let us suppose this distance to be nearly equal to the breadth of one traverse.

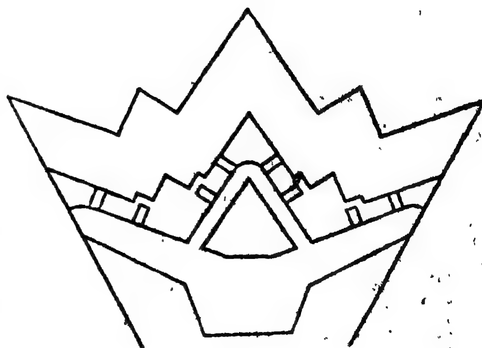
Mark the above distance upon the crest of your glacis, in front of each of the retired traverses; and draw perpendiculars from thence, of the same length, cutting into the glacis.



From the extremities of these perpendiculars draw lines towards the nearest reentering places of arms, parallel to the branches of the covered way.



The perpendiculars and parallels last drawn constitute THE PASSAGES OF THE RETIRED TRAVERSES OF THE COVERED WAY. Rub out the superfluous parts of the original crest of your glacis, and the passages of the retired traverses will be complete.

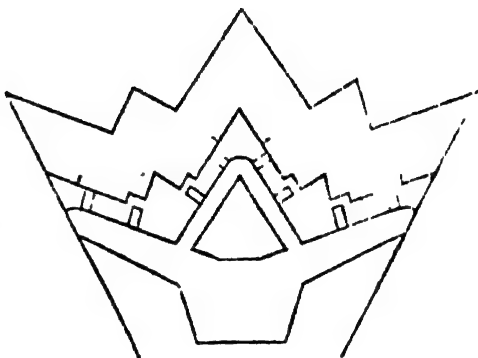


The passages of the retired traverses are always made in the above manner.

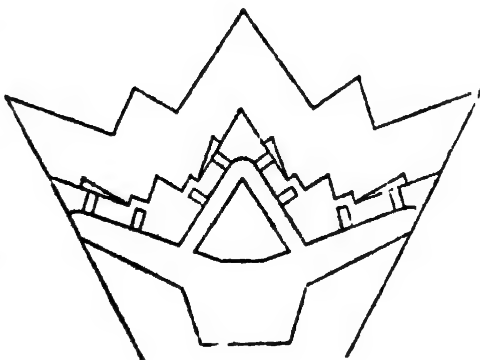
The passages of the advanced traverses are usually made indented. The manner of drawing them is as follows.

Mark a certain distance upon the crest of the glacis, in front of each of your advanced traverses, and from thence draw perpendiculars or lines nearly perpendicular, cutting into the glacis, in order to show the breadth of your indented passages in front:

And let these distances and perpendiculars be equal to those set off in front of the retired traverses, nearly.



Draw right lines from the extremities of these perpendiculars, to the front of the passages of the traverses in rear of them. This will show the new form that must be given to part of the crest of the glacis.



Rub out those parts of the original crest of the glacis, that become imaginary lines; and the form of A COVERED WAY WITH INDENTED PASSAGES OF THE TRAVERSES will be complete.

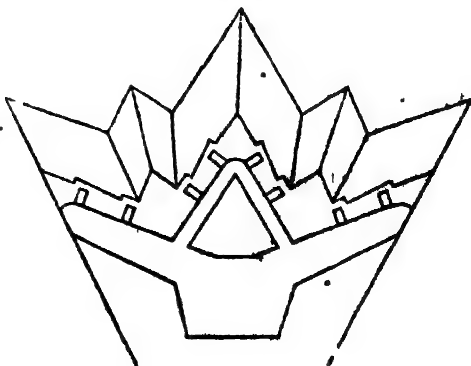
Sometimes, when the branches of the covered way of any work are very long, or much exposed to an enemy's fire; there may be more than two traverses to each branch. In that case, the advanced traverse would be called the first traverse of any branch.

For instance, if a long branch of the covered way had three traverses; the advanced traverse would be called the first traverse, that immediately in rear of it would be called the second traverse, and the retired traverse would be called the third traverse, of that particular branch of the covered way.

The glacis has ridges and furrows across it occasioned by its sloping and angular form.

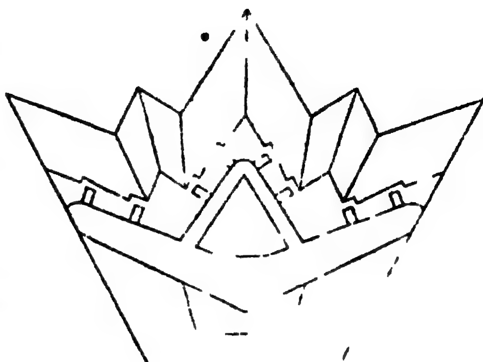
There is a ridge in front of every salient angle of the crest of the glacis; and there is a furrow in front of every reentering angle of it.

Draw THE RIDGES AND FURROWS OF THE GLACIS, by joining the opposite angles of the crest and foot of it.



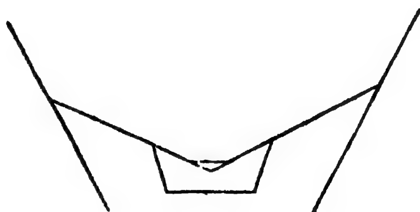
It now only remains to draw THE TENAILS.

Produce the faces of the two demibastions of each front, till they meet in a reentering angle before the curtain. These produced lines will form a part of your original lines of defence. They will also form the faces of your tenails.

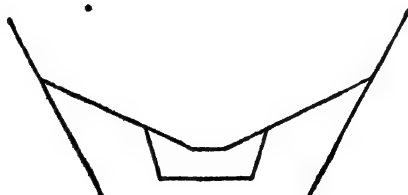


In some of the following figures, which relate solely to the tenail; the ravelin, ditches, covered way, and glacis are omitted for the sake of clearness. It is to be observed that the tenails are usually drawn immediately after the body of the place of a regular fortress is finished. In the book, the construction of this work has been commenced last of all, otherwise many of the figures would have appeared complicated.

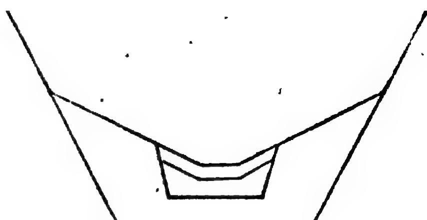
Draw, to each of your tenails, a small curtain, parallel to the curtains of the body of the place, at a given distance.



Rub out the superfluous parts of your lines of defence.



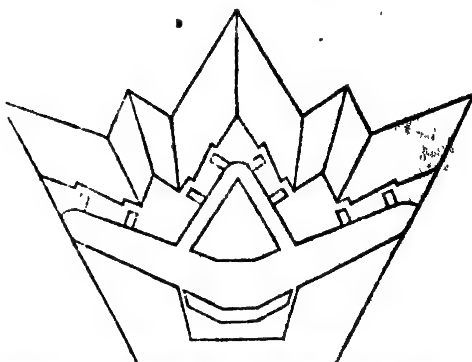
Make the breadth of the tenails equal to a given distance, for instance, let it be equal to one half of the breadth of the main ditch; and draw parallels to the faces and curtain of each tenail, at the above distance, in order to show the reverse of this work.



Draw the extremities of THE TENAILS, parallel to the flanks of the adjoining bastions, at a given distance.



Rub out superfluous lines.



When the learners are drawing a half hexagon:

The plan of a regular half hexagon, having tenails, ravelins, ditches, a covered way with traverses, and a glacis, is now complete.

When they are drawing one front only:

The plan of one front of a regular hexagon, supposed to have tenails, ravelins, ditches, a covered way with traverses, and a glacis, is now complete.

By the same method, you may easily draw the plan of a regular pentagon, heptagon, octagon, or any other kind of polygon.

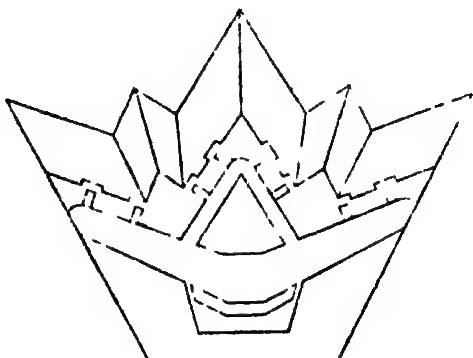
Indented passages of the advanced traverses, such as are represented in your present figure, are the most approved.

Sometimes however the passages of these traverses have been made rectangular.

Rub out the passages of your advanced traverses, and restore the crest of the glacis to its original form.

Setting off upon the crest of the glacis a given distance in front and rear of each advanced traverse, construct a rectangle cutting into the glacis, to show the form of the rectangular passage.

Rub out those parts of the crest of the glacis, which will become superfluous after these passages are drawn.



The form of a work, having a covered way with RECTANGULAR PASSAGES OF THE TRAVERSES, is now complete.

REMARKS.

It was before observed, that in drawing the plan of a regular fortress, it is not usual to rub out any of the imaginary

lines, which are useful in the construction, until the whole of the outline is finished in pencil; although in this book a different practice has been followed, for the sake of rendering the figures more simple, and the directions more clear.

In penning a finished plan with ink, the master line or scarp line of the body of the place must be made a thick line.

The faces of the ravelins, the crest of the glacis, and the crests of the traverses, must also be made thick lines.

The rest of the lines must be made thin.

FURTHER EXPLANATION
OF THE NATURE OF COUNTERFORTS AND TRAVERSES.

From the figures which you have already drawn, the form and nature of the various parts of a regular fortress, at least of such as have been taken into consideration, may appear sufficiently clear; with the exception of the counterforts of the revetments, and the traverses of the covered way. These require some further explanation.

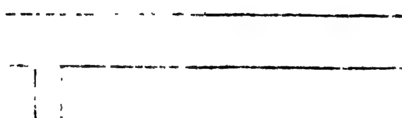
You have already drawn the section of a revetment with counterforts. The plan only is wanting to give a just notion of them.

Draw two lines parallel to each other at a certain distance, to represent the foundation plan of any part of the revetments of a fortress.

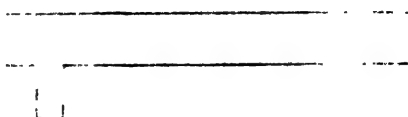
Let the upper line represent the front, while the under line represents the back of the revetment; the distance between the two, of course showing the thickness of the wall at bottom.



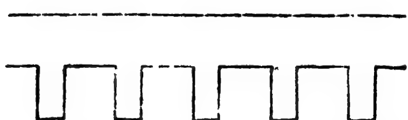
In rear of the revetment, and touching the back of it, draw a rectangle to represent a counterfort, making, as is usually done, the depth of the counterfort greater than its breadth.



Rub out that part of the back of the revetment, which will become superfluous after the counterfort is drawn.



The form of one counterfort is now complete. You will next proceed to draw more counterforts exactly similar and equal to it, at a given distance from each other. For instance, let their distance apart, measured in the clear, be double the breadth of one counterfort.

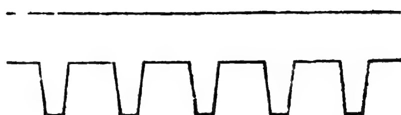


The foundation plan of A REVETMENT WITH RECTANGULAR COUNTERFORTS is now complete. In building the fortress, after the foundations are laid out according to the above plan, the front

of the revetment has a slope, but the counterforts and the back of the revetment are raised perpendicularly.

Counterforts are not always rectangular, sometimes they are made in the form of trapezoids, wider in front than in rear. These are called diminished counterforts.

Rub out your rectangular counterforts, and draw a new set of counterforts equal in number to the former, but wider in front than in rear.



Your figure now represents the foundation plan of A REVETMENT WITH DIMINISHED COUNTERFORTS.

The rear of a counterfort is generally called THE TAIL of it; whilst that part of it, which joins to the revetment, is called THE ROOT.

Diminished counterforts have been more often used than rectangular ones.

I shall next explain to you more particularly the nature of the traverses of the covered way.

It was before mentioned, that the traverses of the covered way are small parapets extending across it, of the same height as the crest of the glacis nearly. We shall now proceed to draw a section of one of them.

Draw a right line to represent the general level of the covered way.

Raise a perpendicular from thence to show the height of the parapet of the traverse: mark a point in rear of it to show the

extent of the base of the interior slope; and draw the interior slope of the parapet of the traverse.



Draw a horizontal line outwards to represent the thickness of the parapet at top: and drop a perpendicular to show its dip.



Draw the superior slope of the parapet; and produce the last mentioned perpendicular downwards, till it meets the ground line.



This produced part represents the height of the exterior slope of the traverse: make the base of this slope equal to its height; and draw the exterior slope.



Draw a banquette of the usual form in rear of the parapet of the traverse; showing the tread of the banquette; its height, and its slope.



The section of your traverse is now finished. It consists, as was

before mentioned, of a simple parapet raised above the general level of the covered way, with a banquette in rear of it.

The salient places of arms being the most advanced, and consequently the most exposed, parts of the covered way; an enemy usually attacks them first. The parapets of the traverses are therefore so constructed, that the fire of troops posted on the banquettes behind them must always be directed towards the salient places of arms.

Sometimes there is a row of palisades, placed on the banquettes of the traverses, exactly like the palisades of the covered way.

Rub out the superfluous lines in the parapet and banquette of your traverse:



And draw a palisade on the front of the banquette, to represent the form of THE PALISADES OF THE TRAVERSES.



Sometimes also there are gates to shut up the passages of the traverses, in order to prevent an enemy, who has taken any of the salient places of arms, from being able to penetrate through these passages, into the remaining parts of the covered way.

These gates are called THE BARRIERS OF THE TRAVERSES.

CHAP. V.

CONSTRUCTION OF THE OUTLINE OF A REGULAR OCTAGON, FORTIFIED ACCORDING TO VAUBAN'S FIRST SYSTEM.

PRELIMINARY REMARKS.

There are various systems of fortification, which have been invented and proposed by different Engineers from time to time; and the same Engineer has sometimes laid down two or three different systems.

In the construction of a regular octagon, which is now about to be explained, and in such of the following constructions as relate to the attack of places, the first system of Vauban has been chosen in preference to any other, for the following reasons.

In the first place; on account of the simplicity of its construction, which renders it most suitable for an elementary work.

Secondly; it is a system which has been much followed in practice, and although improvements in fortification have subsequently been made; yet there are few fortresses to be found, unless favoured with extraordinary advantages by nature, which are actually much stronger, than a place fortified according to this system would be.

Thirdly; it is to be observed; that the same general principles, upon which the attack of a fortress built according to this system ought to be conducted, will also hold good in besieging fortresses constructed according to any other system.

Consequently, in studying fortification, if a learner makes himself thoroughly master of this system, he will afterwards find it a very easy task to understand any other system of fortification, that he may meet with in plans or books, although it may be of a much more complicated nature.

For the above reasons, until you perfectly understand this system, and the attack of it; it is much better not to attempt to study any other.

Having made these preliminary remarks, we shall now commence our construction.

CONSTRUCTION OF A REGULAR OCTAGON, &c.

The construction herein laid down applies to Plate I. of this volume; which is however done on rather a smaller scale, than would be proper for a Learner to commence with.

The Teacher, after every individual direction contained in the following paragraphs, ought to examine the performances of the Learners, before he allows them to proceed further.

Their drawings, when finished, ought to be exactly similar to Plate I., excepting only the above-mentioned difference in the scale.

In studying this work without the assistance of a teacher, the progressive steps in the construction of Plate I. will easily be understood, by referring to the figures annexed to the last chapter, in which a hexagon was chosen as being a simpler figure than an octagon; but the same rules, generally speaking, apply to both.

The construction of Plate I. also applies to a part of the subsequent plates of this work, and therefore the various directions have been numbered, for the sake of a more easy reference from one to the other, when required.

1. Construct a rectangle for the margin or boundary of your drawing, which must be eight and a half regular inches by fifteen.

Take notice, that in this and the following constructions, whenever the term "regular" is used in speaking of any dimension, it implies that the said dimension or measurement is not to be taken from the scale, according to which the plate may be drawn; but that it is to be full-sized standard English measure.

When the term "regular" is not used in speaking of any dimension, it implies that it is to be measured from the scale.

2. The next thing necessary is to draw the scale; which may either be done on some waste part of your paper below the margin, that may afterwards be cut off, or on a separate piece of paper.

When the plate is finished, a new scale will afterwards be constructed within the margin.

The scale for your present plate must be one hundred yards to an inch. It is constructed as follows.

Draw a right line six regular inches long, and divide it into six equal parts.

Subdivide the first or left hand division into ten equal parts: and make the middle subdivision more conspicuous than the others.

Each of your large divisions will then represent 100 yards, whilst each of the subdivisions at the left of your scale will represent 10 yards.

You will therefore place the number 100 under the left extremity of your scale; under the middle subdivision place the number 50; at the end of the first division write the figure 0; and from thence

under each of the remaining large divisions write successively the numbers 100, 200, 300, 400, and 500.

3. Let one of the long sides of your margin be the bottom line of your drawing. Bisect it; and from the middle of it, as a center, with a radius of 502 yards, describe a semicircle.

4. Divide the circumference of your semicircle into four equal parts, and mark them by points.

5. Bisect each of these divisions, and mark four new points on the circumference for this purpose.

6. Connect these four last marked points by right lines, which will form three sides of a regular octagon, each of which will be 384 yards long.

If the polygon, proposed to be fortified, were less or greater than an octagon, in that case a smaller or greater radius than the above would be necessary, in order to obtain an exterior side of 384 yards; this having in all cases been considered a good proportion for the length of the exterior sides of a regular fortress.*

7. From the first points marked on the circumference, draw radii or right lines directed towards the center. These will bisect the sides of your polygon; and consequently upon these, the perpendiculars of your fortress must be set off.

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* This is equal to 180 french toises, the length adopted by Vauban for the exterior sides of his polygon. It may here be observed, that in order to obtain an exterior side of 384 yards precisely, for a regular octagon, the radius should not be exactly 502 yards, as stated in paragraph 3d, but a small fraction less. The difference however is so trifling, that it was not worth while to notice it in practice.

8. Measure the distance, from the outer extremity of any of these radii, to the point where it is intersected by one of the sides of your polygon, and set off an equal distance from each extremity of your diameter towards the center.

9. Connect the two points, thus marked on your diameter, to the nearest extremities of the finished sides of your polygon, by right lines.

Each of these two last drawn lines will be exactly one half of the side of your polygon.

Your present figure, therefore, consists of three sides or fronts of a regular octagon and of two half-sides of the same. Consequently it represents exactly one half of a regular octagon, which is to be fortified.

10. Make your perpendiculars each 64 yards long, which is equal to one sixth of the exterior side.

11. From the exterior angles of the polygon, draw the lines of defence intersecting each other at the foot of each perpendicular.

12. Make the faces of your bastions 110 yards long, which is equal to two sevenths of the exterior side nearly.

13. Take the distance between the salient angle of any bastion, and the shoulder of an adjoining one, as a radius, and from every salient angle, as a center, make intersections upon those lines of defence which are drawn from the same point.

These intersections will give you the position of the angles of the flank of the three whole fronts of your figure.

14. Draw the flanks of these three fronts.

15. Draw also their curtains.

The two half fronts at the extremities of your figure remain to be finished; which cannot be done by the above rule, as some of the points that ought to be used, fall without the semicircle.

The method of constructing them is as follows.

16. Draw the capitals of the right and left demibastions of your finished fronts.

17. Find the points, where the demigorges of these demibastions intersect their capitals, by producing the adjacent curtains.

18. From these points of intersection, draw lines parallel to the half exterior sides, extending as far as the diameter.

19. From the same points, upon each of the last drawn lines, set off a distance equal to the length of a demigorge.

This will give you the position of the angle of the flank of each of your two half fronts. The length of their faces was marked before.

20. You will therefore draw the flanks of these two half fronts by joining the proper points.

The body of the place of your half octagon is now complete.

21. From the salient angle of every bastion, as a center, with a radius of 32 yards, describe arcs, outwards.

22. Draw tangents to these arcs in the direction of the shoulders of the opposite bastions.

This will give you the form of the main ditch and counterscarp of your three whole fronts.

The counterscarp at the extremities of your half octagon will still remain unfinished, because the points necessary for the direc-

tion of the tangents, fall without the semicircle. The method of completing it is as follows.

23. Upon the perpendicular of any of your finished fronts, measure the distance from the point where it is intersected by the exterior side to the reentering angle of the counterscarp: and set off an equal distance from each of the corresponding points, inwards, upon the perpendiculars of your two half fronts.

The two points thus found will be the reentering angles of the counterscarp of your half fronts, which remain unfinished.

24. Draw your two remaining tangents accordingly, directing them upon these points; and the main ditch of your half octagon will then be complete.

25. From all the reentering angles of the counterscarp set off 85 yards, outwards, upon the perpendiculars produced, in order to show the length of the capitals of the ravelins.

26. Set off 11 yards upon the face of each bastion, measuring from the shoulder towards the salient angle.

27. From the extremities of the capitals of your ravelins, draw right lines in the direction of the last marked points.

These right lines will be the faces of your ravelins.

28. From the reentering angle at the gorge of each ravelin, set off 24 yards, right and left, upon each demigorge.

29. Join the points thus found by right lines, which will give you the break at the gorge of your ravelins.

30. From the salient angle of every ravelin, as a center, with a radius of 21 yards 1 foot, describe arcs outwards, for the breadth of the ditches of the ravelins.

31. To these arcs draw tangents, parallel to the faces of the ravelins.

This will complete the ditches of the ravelins, and the whole of the counterscarps of your fortress.

The faces of the tenails are formed by the meeting of the two lines of defence in every front.

32. Draw a small curtain to each tenail, parallel to that of the body of the place, at the distance of 32 yards.

33. Make your tenails 17 yards wide throughout, and draw the reverse of each.

34. Draw the extremities of your tenails, parallel to the flanks of the body of the place, at the distance of 11 yards.

35. At the distance of 10½ yards, draw lines parallel to the counterscarp, to show the breadth of the covered way, and crest of the glacis.

36 On each side of the reentering angles of the crest of the glacis, set off 36 yards for the demigorges of the reentering places of arms of the covered way.

37. Draw the faces of the reentering places of arms, making them each 40 yards long.

38. At the distance of 72 yards, draw lines parallel to all the faces of the covered way, which will give you the breadth of the glacis.

39. Produce the faces of all the bastions and ravelins until they cut the counterscarp.

40. From the center of the circular part of the counterscarp of any of your ravelins, measure the distance to either of the adjoining points, marked on the counterscarp of the same ravelin by one of its faces produced.

And set off the same distance, in the same manner, upon the counterscarps of the two half ravelins at the right and left extremities of your figure.

41. From the various points marked on your counterscarp, draw perpendiculars across the covered way.

These perpendiculars will represent the front of your advanced traverses.

42. From all the reentering angles of the covered way, draw perpendiculars across it, for the back of the retired traverses.

The advanced and retired traverses are not always made exactly of the same breadth or thickness. Let us suppose that they are of unequal breadths.

43. Make your retired traverses 6 yards broad; but make your advanced traverses only 4 yards broad; and draw parallel lines at the above distance, to show their respective breadths.

44. The branches of the covered way of the ravelins must have three traverses. You will therefore draw a central traverse 4 yards broad, in each of them, exactly in the middle between the two former traverses of the same branch.

45. Set off 5½ yards upon the crest of the glacis, in front of your traverses, for the breadth of the passages.

46. From all these points, with a radius of 5 yards, describe arcs cutting into the glacis, for the depth of the passages of the traverses.

All the passages of the traverses must be tangents to the above arcs.

47. Draw tangents parallel to the crest of the glacis for the passages of the retired traverses.

48. Draw oblique tangents for the passages of the remaining traverses, which must be made indented.

49 From the center of each small arc, draw a perpendicular to the tangent of the same arc.

This being done, the whole of the covered way will be complete.

50. Draw the ridges and furrows of the glacis.

51 Pen your drawing, and let the body of the place, the front of the tenail, the faces of the ravelins, the crest or back of each traverse, and the crest of the glacis, be all marked with thick lines, making the remaining lines thin.

Observe also, that it is usual to pen with red ink, all those lines of a fortress which are supposed to be reveted; the above being the colour chosen to denote masonry. For instance, in your present drawing, the whole of the outline might be so marked, with the exception of your glacis and traverses, which ought to be penned black.

52. Write in large letters the words OUTLINE OF A REGULAR OCTAGON, in any convenient place, as the title of your drawing.

53. Draw a new scale in any convenient place within the margin, and near the bottom of it; pen it, and write over it *Scale of 100 yards to an inch.*

54. The margin is usually finished with double lines; a second set of parallel lines being drawn a little without the original rectangle. In penning the margin, the outside lines are made thicker than the interior rectangle.

Finish your margins accordingly.

55. In drawing plans of fortification, dates and signatures are usually inserted near the bottom of the margin, the former towards the left of the paper, the latter on the right.

Insert dates and signatures accordingly.

CHAP. VI.

REMARKS ON THE GENERAL PROFILE OF WORKS OF FORTIFICATION.—SECTIONS OF A REGULAR FORTRESS CONSTRUCTED BY SCALE.

In a regular fortress, all those parts, which correspond with each other in the plan, have the same general profile or section nearly, throughout their whole extent.

For instance, as far as regards the body of the place, a section, taken through one of the faces or flanks of any one bastion, will agree nearly in all its dimensions, with another section, taken through any part of any other bastion of a fortress. A section, taken any where through any one curtain, will also agree with a section of any other curtain: and moreover, a section, taken through any part of the bastions, will agree nearly with a section, taken through any part of the curtains, of the same fortress.

In like manner, a section, taken through any part of either of the faces of one ravelin, will agree nearly with any other section, taken through a part of the face of any other ravelin, of the fortress.

It is to be observed, that the profile of the ravelins resembles that of the body of the place, in all its parts, but with this difference, that the ravelins are always made some feet lower than the body of the place.

The main ditch is of the same depth nearly throughout its whole extent; and the ditches of all the ravelins have the same section throughout; their depth being generally, but not always, equal to that of the main ditch.

The covered way is every where of the same general height; and the crest of the glacis is also of the same height nearly, all round.

Consequently not only the body of the place and ravelins, but also the ditches, covered way and glacis, of a regular fortress, have the same general profile throughout their whole extent; and sections taken through any part of them whatever, will nearly agree with each other, excepting only that, as far as regards the breadth of the main ditch and covered way, there will necessarily be a variation, according to the part through which the section may be taken, these works being broader in some parts than in others, as was shown in the plan.

It will have been clearly understood from what I have already said, that the various works of a regular fortress are nearly of the

height in all the corresponding parts. Their height, however, although nearly, is not every where exactly the same: but the difference, which shall now be mentioned, is very trifling.

The faces of the bastions fall gradually in height, each way, from the salient angle towards the angles of the shoulders; the difference being usually about one foot, or one foot and a half.

The flanks are of the same height as the shoulders or lowest part of the adjoining faces: and the curtains are equal in height to the flanks.

The faces of the ravelins, like those of the bastions, usually fall about one foot from the salient angle towards their other extremities.

And the glacis of the bastions is generally made about one foot higher than that of the ravelins.

Thus as the difference of height in all the corresponding parts, such as the body of the place, the ravelins, and glacis, does not usually any where exceed one foot and a half; the general profile of a regular fortress is so very nearly uniform throughout its whole extent, that two sections of a very simple nature will be quite sufficient to explain it.

I shall now proceed to teach you the method of constructing these sections by scale. They may both be conveniently contained in the same drawing, which will consequently consist of two figures.

The first figure will nearly agree in all its parts with the rough section which you before drew, according to the directions given in Chap. III.

FIGURE I.

SECTION THROUGH THE FACE OF A BASTION, MAIN DITCH, COVERED WAY AND GLACIS.

The drawing which the Learner is now directed to execute, will, when finished, be exactly similar to Plate II., with this difference only, that the latter is done on rather a smaller scale.

1. Draw a rectangle for your margin, which may be twelve regular inches by twenty-six.

2. Make a scale for your first figure, of twenty feet to an inch. It is constructed as follows.

Draw a line five regular inches and a half long: divide it into eleven equal parts: subdivide the first of these divisions into ten equal parts; and make the middle subdivision more conspicuous than the others.

Write the number 10 under the left extremity of your scale; and from thence under each large division place successively the figure 0, and the numbers, 10, 20, 30, &c. as far as 100.

3. Draw the ground line of your first figure, parallel to the top of your margin, at the distance of about four regular inches and a quarter below it.

4. At any convenient distance near the left side of your margin, for instance at about two regular inches from it, mark a point on your ground line; and from thence set off 17 feet 6 inches for the base of the interior slope of the rampart.

Make the height of it also 17 feet 6 inches, and draw the interior slope of your rampart.

5. Make your terreplein 39 feet broad, and 18 feet high in front, and draw your terreplein.

6. Make your parapet 7 feet 6 inches higher than the front of the terreplein: set off for the base of its interior slope, 2 feet 6 inches, which is one third of its height; and draw the interior slope of your parapet.

7. Make your parapet 18 feet thick at top: give it a dip of 3 feet 6 inches, which is in the proportion of one fifth nearly; and draw the superior slope of the parapet.

8. Produce the dip of your parapet 13 feet downwards, in order to represent the height of the exterior slope: make the base of the exterior slope also 13 feet, which is equal to its height; and draw the exterior slope of your parapet.

9. Mark a point on the interior slope of the parapet, 4 feet 4 inches below the crest of it, to show the level of the banquette. Make the banquette 4 feet broad: drop a perpendicular to show the height of it in rear: make the base of the slope of the banquette double its height; and draw the slope of your banquette.

10. Produce the base of the exterior slope of your parapet 1 foot outwards, which leaves a small berm; and drop a perpendicular of 31 feet, for the height of your scarp revetment.

11. Make the base of the slope of the revetment, 5 feet 2 inches, which is one sixth of its height; and draw the slope of your scarp revetment.

12. Set off an offset of 1 foot: make your foundation 3 feet deep: make your revetment 7 feet 8 inches thick at top; and draw the foundation and the back of your scarp revetment.

13. Draw a counterfort behind your scarp revetment 10 feet long; and of the same height as the revetment.

14. Make your cordon 1 foot high above the top of the revetment: let it project 6 inches beyond the scarp line in a semicircular form; and draw the back of it at the distance of 2 feet 6 inches behind the scarp line. Consequently the total length of the cordon will be 3 feet.

15. Set off 96 feet upon the ground line for the breadth of the main ditch, taking care to measure this distance from the scarp line, not from the slope of the revetment; and recollect that this is the rule always observed, in fortification, in measuring the breadth of ditches.

16. From the point thus found, drop a perpendicular of 22 feet to show the height of the revetment of your counterscarp, which is equal to the depth of the ditch; and draw the bottom of the main ditch.

This perpendicular will agree with the counterscarp line, in the outline of the plan of a regular fortress.

17. Make the base of the slope of the counterscarp revetment 3 feet 8 inches, which is equal to one sixth of its height; and draw the slope of your counterscarp revetment.

18. Give the counterscarp revetment an offset of 1 foot: make the foundation of it 3 feet deep: make it 3 feet 9 inches thick

at top: and draw the foundation and the back of your counterscarp revetment.

19. Draw the counterfort of your counterscarp, making it 5 feet long, and 1 foot lower than the revetment.

20. Measure 31 feet 6 inches upon the ground line for the breadth of the covered way: raise a perpendicular of 9 feet for the height of the crest of the glacis; from the top of which mark 7 feet 6 inches, downwards, for the bottom of the parapet of the covered way.

We shall next proceed to draw the coping of the counterscarp, observing previously that there will be a slight difference between this, and the rough section, which you before drew.

In your former section the top of your coping agreed with the ground line *nearly*; whereas in our present figure, we shall make the bottom of the coping agree with our ground line: consequently the covered way, which we are now about to draw, will be a little more elevated above the natural level of the ground, than the covered way of our former section was supposed to be.

21. In rear of your counterscarp revetment, set off 6 inches upon the ground line, for the projection of the coping; and raise a perpendicular of 1 foot to show the height of it in rear.

From the top of this perpendicular, draw a right line to the bottom of the parapet of the covered way, in order to show the general level of the covered way, which has a gentle slope, as was before explained: and make your coping 3 feet long.

22. Draw the interior slope of the parapet of your covered way, making the base of it 2 feet 6 inches, which is one third of its height.

23. Draw the banquette of your covered way, making it 4 feet

4 inches lower than the crest of the glacis; and 5 feet wide, with a slope of double its height.

24. Draw the palisade of the covered way, placing the front of it 6 inches behind the bottom of the parapet: let it be 6 inches thick: make it pointed at top, and let it stand 6 inches higher than the crest of the glacis.

25. Set off 216 feet upon the ground line, for the breadth of the glacis; and draw the slope of your glacis, the base of which is to its height in the proportion of 24 to 1.



FIGURE II.

SECTION THROUGH THE CURTAIN, TENAIL, RAVELIN, COVERED WAY, AND GLACIS.

26. Draw a new ground line, about five regular inches and a quarter, below that of your former figure.

27. The section, which we are now about to draw, being much longer than the last, must be done on a smaller scale, in order to bring it within the limits of the same margin.

You will therefore make a new scale of thirty feet to an inch to suit your present figure. This is done as follows.

Draw a line five regular inches and two thirds in length: divide it into seventeen equal parts: subdivide the first of these divisions into ten equal parts; and make the middle subdivision more conspicuous than the others.

Write the number 10 under the left extremity of your scale; and from thence under each large division place successively the figure 0, and the numbers 10, 20, 30, &c. as far as 160.

28. Near the left side of your margin, for instance at about a quarter of a regular inch from it, set off 16 feet 6 inches on your

ground line for the base of the interior slope of the rampart. Make the height of it also 16 feet 6 inches, and draw the interior slope of your rampart accordingly.

29. Draw your terreplein, making it 39 feet broad, and 17 feet high in front.

30. Make your parapet 7 feet 6 inches high; and draw its interior slope, giving it a base of 2 feet 6 inches, which is one third of the height.

31. Make your parapet 18 feet thick at top: give it a dip of 3 feet which is in the proportion of one sixth: and draw the exterior slope of it, making the base and the height each 12 feet 6 inches.

32. Draw the banquette, making it 4 feet 4 inches lower than the crest of the parapet; and 4 feet wide, with a slope of double its height.

33. Draw a berm of 1 foot, and drop a perpendicular of 31 feet, for the height of the scarp revetment.

34. Draw your scarp revetment, making it 7 feet 6 inches thick at top; with a slope of 5 feet 2 inches which is one sixth of its height; an offset of 1 foot, and a foundation 3 feet deep.

35. Draw a counterfort 10 feet long, and of the same height as the scarp revetment.

36. Draw a cordon 1 foot high above the revetment, projecting 6 inches in a semicircular form, and 3 feet long, including the projection.

The section or profile of the rampart of the curtain is now complete, which is one foot lower than that of the bastion, as represented in your former figure, but is nearly similar and equal to it in every other respect.

37. Make the ditch between the curtain and tenail 45 feet broad; mark this distance on the ground line, in front of your scarp line, according to the rule before mentioned: drop a perpendicular of 22 feet for the foot of the gorge revetment of the tenail; and draw the bottom of the ditch.

38. Upon the last drawn perpendicular, mark 9 feet below the ground line, for the top of the gorge revetment of your tenail, which will leave 13 feet for the height of it above the bottom of the ditch. Make the gorge revetment of your tenail 3 feet 3 inches thick at top: give it a slope of 2 feet 2 inches, which is one sixth of its height; an offset of 1 foot, and a foundation 3 feet deep.

39. Draw a counterfort to the gorge revetment of your tenail, making it 4 feet long, and 1 foot lower than the revetment.

40. Intersect your ground line by a perpendicular, at the distance of 28 feet 6 inches, measured horizontally, in front of the gorge of your tenail; upon which perpendicular mark a point 1 foot 9 inches above the ground line, for the interior crest of the parapet of the tenail: and from this point, downwards, set off 7 feet 6 inches, for the height of the said parapet.

41. Produce the top of the gorge revetment of your tenail 6 inches backwards, to show the projection of a coping; and raise a perpendicular of 1 foot for the height of it.

From the top of this perpendicular draw a right line to the bottom of the parapet of your tenail, in order to show the general level of the interior, or terreplein of the tenail: and make your coping 3 feet long.

42. Draw the interior slope of the parapet of your tenail, making the base of it 2 feet 6 inches, which is one third of the height.

43. Make the parapet of your tenail 18 feet thick at top : give it a dip of 2 feet 3 inches, which is in the proportion of one eighth ; and make the base and height of its exterior slope each 3 feet 6 inches.

44. Draw the banquette of your tenail, making it 4 feet 4 inches lower than the crest of the parapet, and 4 feet wide, with a slope of double its height.

45. Set off a berm of 1 foot, and drop a perpendicular of 18 feet for the height of the scarp revetment of your tenail.

46. Make the scarp revetment 5 feet thick at top: give it a slope of 3 feet, which is one sixth of its height: give it an offset of 1 foot, and a foundation 3 feet deep; and draw a counterfort in rear of it, 5 feet 8 inches long, and of the same height as the revetment.

47. Draw a cordon, 1 foot high above the revetment, projecting 6 inches in a semicircular form, and 3 feet long, including the projection.

48. Set off 165 feet upon the ground line for the breadth of the main ditch between the tenail and ravelin.

Drop a perpendicular of 22 feet, the foot of which will show the bottom of the revetment at the gorge of the ravelin; and draw the bottom of the main ditch.

49. Mark 1 foot below the ground line, for the top of the gorge revetment of your ravelin, the height of which will consequently be 21 feet. Make the said revetment 3 feet 9 inches thick at top; give it a slope of 3 feet 6 inches, which is one sixth of its ht; an offset of 1 foot, and a foundation 3 feet deep.

50. Draw a counterfort to the gorge revetment of your ravelin, making it 5 feet long, and 1 foot lower than the revetment.

51. Measure 75 feet from the gorge of your ravelin, and raise a perpendicular of 1 foot 6 inches, for the position of the bottom of the interior slope of the rampart of your ravelin.

52. Produce the top of the gorge revetment of your ravelin 6 inches backwards, to show the projection of a coping; and raise a perpendicular of 1 foot for the height of it.

53. From the top of your coping, which will agree with the ground line, draw a right line to the top of your former perpendicular. This will show the general level of the interior of the ravelin, which has a gentle slope towards the rear.

Make your coping 3 feet long.

54. Set off 12 feet upon the ground line for the extent of the base of the interior slope of the ravelin. From thence raise a perpendicular of 13 feet 6 inches for the height of this slope above the level of the ground line; and draw the interior slope of the rampart of the ravelin.

It is to be observed, that the base and height of this slope, if this rule is followed, will be exactly equal, each of them being 12 feet; because the bottom of the slope, which was before marked, was 1 foot 6 inches higher than the ground line.

55. Draw the terreplein of your ravelin, making it 30 feet broad, and 14 feet higher than the ground line in front.

56. Make the parapet of your ravelin 7 feet 6 inches high: give it an interior slope of 2 feet 6 inches, which is one third of its height: make it 18 feet thick at top; with a dip of 3 feet 6 inches, which is in the proportion of one fifth nearly; and draw its exterior slope, making the base and the height each 10 feet.

57. Draw the banquette of your ravelin, making it 4 feet 4 inches lower than the crest of the parapet, and 4 feet wide, with a slope of double its height.

58. Draw a berm of 1 foot, and drop a perpendicular of 30 feet, for the height of the scarp revetment of your ravelin.

59. Make the scarp revetment of your ravelin 7 feet thick at top: give it a slope of 5 feet, which is one sixth of the height give it an offset of 1 foot, and a foundation 3 feet deep; and draw a counterfort in rear of it, 9 feet 3 inches long, and of the same height as the revetment.

Draw a cordon 1 foot high above the revetment, projecting 6 inches in a semicircular form, and 3 feet long, including the projection.

60. Set off 64 feet upon the ground line for the breadth of the ditch of the ravelin: drop a perpendicular of 22 feet, the foot of which will show the bottom of the counterscarp revetment; and draw the bottom of the ditch of the ravelin.

61. Mark 1 foot below the ground line for the top of the counterscarp revetment of your ravelin, the height of which will consequently be 21 feet. Make the said revetment 3 feet 9 inches thick at top: give it a slope of 3 feet 6 inches, which is one sixth of its height; an offset of 1 foot, and a foundation 3 feet deep.

Draw a counterfort to the counterscarp of your ravelin, making it 5 feet long, and 1 foot lower than the revetment.

62. Set off 31 feet 6 inches on the ground line, for the breadth of the covered way of your ravelin; and raise a perpendicular of 8 feet for the height of the crest of the glacis; from the top of which mark 7 feet 6 inches, downwards, for the bottom of the parapet of the covered way.

63. Produce the top of the counterscarp revetment of your ravelin 6 inches backwards, to show the projection of a coping: and raise a perpendicular of 1 foot for the height of it.

64. From the top of this perpendicular, which will agree with the ground line, draw a right line to the bottom of the parapet of the covered way, in order to show the general level of the covered way of the ravelin: and make your coping 3 feet long.

65. Draw the interior slope of the parapet of the covered way of your ravelin, giving it a base of 2 feet 6 inches, which is one third of its height.

66. Draw the banquette of the covered way of your ravelin, making it 4 feet 4 inches lower than the crest of the glacis: and 5 feet broad: with a slope of double its height.

67. Draw the palisade of the covered way of your ravelin, placing the front of it 6 inches from the bottom of the parapet: let it be 6 inches thick: make it pointed at top; and let it stand 6 inches higher than the crest of the glacis.

68. There is not quite room within the limits of your margin for the whole breadth of the glacis, which ought to be 216 feet. In order to find the true proportion of the slope, you will therefore set off 108 feet, which is exactly one half of the above distance; from thence raise a perpendicular of 4 feet, which is one half of the total height of the glacis of your ravelin; and draw a right line, from the crest of the glacis through the top of the above perpendicular, which you will produce as far as the margin will permit.

This right line will represent the slope of the glacis of the ravelin, which is in the proportion of 27 feet to 1, and is therefore

a little less steep than the slope of the glacis of the bastion, which was 24 feet to 1, as before mentioned.

Most writers recommend that every part of the glacis should have exactly the same slope, which might easily have been done in the present instance, by reducing the base of the slope of the glacis of the ravelin from 216 to 192 feet; but this did not appear to me necessary, because the difference between the two proportions above mentioned is very trifling.

It is to be observed, that there are objections against giving either too much or too little slope to a glacis; and that 24 feet to 1 is usually considered a good proportion.

69 Pen your drawing; marking by red lines all those parts, which represent masonry or brickwork, such as the various revetments, counterforts, cordons, and copings. Do the remainder of it with indian ink, dotting the ground line, and other imaginary lines, that were useful in the construction; and finish the margin with double lines, in the usual manner.

If you choose to colour your drawing, lay a moderately light shade of red over all the revetments, cordons and copings: lay a still lighter shade of the same colour over the counterforts; and over the remaining parts, which represent earth and rubbish, lay a shade resembling the colour of sand.

Sometimes this shade is laid on smooth to a regular distance below the ground line, and parallel to it, so as to comprehend all the lowest parts of the section. Sometimes it only extends a little below the general outline of the figure, following the form of it.

The last-mentioned method of laying on this colour is shown in

Plate II., where it is represented by small dots, which is the usual mode of denoting sand or earth, in engraved plans and sections.

In drawings of fortification, but more especially in sections, it is often usual to write dimensions opposite to each of the principal parts represented, in order to save the trouble of measuring them from the scale.

Whenever there are several points near each other, so that it might be doubtful to which of them the dimensions, written on a plan or section, are intended to apply; then, in order to prevent mistakes, the two particular points, between which any written dimension has been measured, are denoted by small broad arrows, or marks resembling the letter V, the angular points of the two marks being placed outwards, at the extremities of the distance measured, in contrary directions, with their angles or openings facing towards each other.

When two written distances are measured from any central point, then the extreme points are marked as above; but the central point has two marks joined together, to denote that dimensions are set off from it in two different directions.

The double mark, thus formed by the meeting of two broad arrows on the same point, resembles the letter X.

Having made this remark, we shall now proceed to write down or mark the principal dimensions in Fig. 1.

70. First, as far as regards lengths: mark, upon your ground line, the base of the interior slope of the rampart; the breadth of the terreplein, and the breadth of the glacis.

71. Mark near the top of each, the thickness at top of your

scarp and counterscarp revetments, and the length of their respective counterforts.

Mark also the base of the slope of each of the above revetments.

72. From the crest of the parapet you have already drawn a horizontal line outwards. Produce it until it meets a perpendicular, raised from the crest of the glacis.

Produce also the scarp line, and counterscarp line upwards, until they meet the above horizontal line: and dot the whole of these new lines.

73. Then mark the following dimensions on your horizontal line, namely:

The thickness of your parapet at top;

The total extent of the base of the exterior slope and of the berm added together, which is 14 feet;

The breadth of the main ditch;

And lastly the breadth of the covered way.

On examining your section attentively, you will observe, that the above distances, namely, the thickness at top of the parapet; the base of its exterior slope and berm; the breadth of the main ditch and that of the covered way; could not be marked in any way without creating confusion, unless by transferring them to a horizontal line drawn for the purpose, as above directed, in a place which does not interfere with the figure.

74. You will next mark the following heights, namely;

The height of the interior slope of the rampart; the total height of the parapet above the ground line; the height of the exterior slope of the parapet; and the dip of the parapet.

75. Mark also the perpendicular height of the scarp and counterscarp revetments, above the level of the bottom of the ditch, without including the cordon or coping.

76. Mark the depth of the foundation of these revetments: and the height of the crest of the glacis above the ground line.

77. Lastly mark the height from the crest of the glacis to the horizontal line, which was drawn from the crest of the parapet outwards.

This dimension, which is 16 feet 6 inches, will show the difference of level between the body of the place and the crest of the glacis.

All your principal dimensions are now marked, nothing being omitted but the details of the interior slope of your parapets, your banquettes, cordon, coping and palisade; the whole of which are very simple: and as they occur in almost every section, and are nearly the same in all, you ought to know and keep in mind the dimensions which are most suitable for them.

It may here be remarked, that it is common, in sections, in any convenient place not likely to interfere with the figure, to draw a dotted vertical line, to which the height of various parts may be transferred and their dimensions marked, for the sake of clearness; in the same manner as some of our distances in this figure were transferred to a dotted horizontal line.

A vertical line, thus used, becomes a scale of heights, the nature of which, and the method of transferring heights to it from any part of a figure, were fully explained in the first volume, in treating of the Principles of Plan Drawing.

It has not been judged necessary to use a scale of heights in our present figure, as the principal dimensions can be marked in a manner sufficiently clear without it; but you may often observe it in sections, that you are likely to meet with hereafter.

78. In Fig. 2, you will mark the following dimensions only, all measured from the ground line upwards, which will serve to explain the relative heights of the principal works, namely:

The height of the interior crest of the parapet of the curtain; as also of that of the ravelin; and lastly the height of the crest of the glacis of the ravelin.

79. Over your first section write, in a conspicuous manner, the words, *Fig. 1. Section through the Face of a Bastion, Main Ditch, Covered Way and Glacis.* And under this section, in any convenient place, insert the scale properly finished, writing above it, in small letters, *Scale for Fig. 1, of 20 feet to an inch.*

80. Over your second section, write, in a conspicuous manner, the words, *Fig. 2. Section through the Curtain, Tenail, Ravelin, &c.* And under this section, in any convenient place, insert the scale, writing above it, in small letters, *Scale for Fig. 2, of 30 feet to an inch.*

It is to be observed, that the sections you have just drawn, are not taken in one uniform direction throughout, that is to say they are not taken according to any continued right lines drawn from the interior of the fortress to the foot of the glacis; but according to a line which is supposed to change its direction, from time to time, in such a manner, that the section shall always cut perpendicularly across each part of the fortress, which it is intended to represent.

The reason, that sections must always be taken perpendicularly, was explained in that part of the first volume, which treats of the Principles of Plan Drawing : but on inspecting the plan of a regular fortress, you will perceive at once, that no continued right line can possibly cut all the various works perpendicularly.

For instance, if you draw a right line perpendicularly through a curtain any where near the middle of it, it will also cut the curtain of the tenail and the break at the gorge of the ravelin perpendicularly, because all these works are parallel to each other ; but if you produce the same line further towards the country without changing its direction, it must necessarily cut obliquely through the ravelin, &c. because the face of the ravelin is oblique to the curtain.

The drawing, which you have now finished, contains the two principal and most useful sections of a regular fortress ; and if you pay proper attention to these sections, and to the outline of the half octagon, which you before drew, you cannot fail to have a good idea of the general nature of a fortified place.

In order to give you a complete notion of the whole, it only remains to explain the nature of some particular parts in detail, such as the gates, bridges, &c.

These details, when considered separately, will prove to be of a very simple nature : but before we proceed to notice them, I shall add a few more remarks upon the profile.

ADDITIONAL REMARKS.

From the preliminary remarks at the beginning of this chapter, it will have been understood, that the term "general profile" implies more

especially the consideration of the relative heights of the various works, and of the relative depths of the various ditches, of a fortress. The same thing is often expressed by the word relief.

Since THE GENERAL PROFILE OR RELIEF OF WORKS may vary considerably, without any difference in their plan; any fortress, which has higher ramparts and revetments and deeper ditches than another, is said to have a stronger or bolder profile, or in other words a bolder or greater relief, than the other.

In like manner, when considered individually, A WORK IS SAID TO HAVE MORE OR LESS RELIEF in proportion to its height.

In fortification, when any work is raised higher than another, it is said TO COMMAND it, or to have a command over it.

For instance in our first figure, the parapet of the bastion is 25 feet 6 inches higher than the ground line; whilst the crest of the glacis is only 9 feet higher than the same level.

Consequently the face of the bastion, through which the section is taken, would be said to have a command of 25 feet 6 inches over the country, and a command of 16 feet 6 inches over the crest of the glacis.

In the second figure, the curtain is elevated 24 feet 6 inches above the ground line, whilst the ravelin is elevated only 21 feet 6 inches, and the crest of the glacis of the ravelin 8 feet, above the same level.

Consequently if these various heights are compared together, the bastion will be 1 foot higher than the curtain: it will have a command of 4 feet over the ravelin, and of 17 feet 6 inches over

the glacis of the ravelin, which is one foot more command, than it has over its own glacis.

The curtain has a command of 3 feet over the ravelin, of 15 feet 6 inches over the glacis of the bastion, and of 16 feet 6 inches over the glacis of the ravelin.

The ravelin has a command of 13 feet 6 inches over its own glacis, but of 12 feet 6 inches only, over the glacis of the bastion.

The body of the place is always made higher than the ravelins, and the ravelins higher than the glacis, in every regular fortification. In short, as a general rule, it may be observed, that those parts of a fortress, which are nearest to the center of the place, should invariably be higher or more commanding, than such other parts of it, as are more advanced towards the country.

The reason is, that both cannon and musquetry, in almost all cases, act with greater effect, when fired downwards from a commanding work, than when directed from any low situation, upwards, against a higher one; and as an enemy, in attacking a fortress, must necessarily take the most advanced works first, it has therefore been judged best to make them the lowest.

Consequently when a besieging army have taken the glacis and covered way, they find themselves exposed to a more commanding fire from the ravelins and bastions; and after they have taken the ravelins or other outworks, they are then exposed to a commanding fire from the body of the place.

The general rule, in respect to the command of works, which has just been given, does not apply to the tenail. This work,

although nearer to the center of the place than the ravelin, is made much lower than the latter. It is even sometimes made lower than the glacis, but not always: the more usual practice being to construct it of the same height as the crest of the glacis nearly.

The reason that the tenail forms an exception to the above rule is, that this work is intended chiefly as a screen to cover a part of the revetments of the body of the place, and particularly those of the curtain; which is a matter of importance, on account of the gates or sallyports that are usually placed there.

This being the case, the tenail is always kept as low as possible, consistently with the above object, in order that those parts of the body of the place, which are behind it, but more especially the flanks, may be able to fire over it with good effect.

In the sections, which you have just drawn, the tenail is made lower than the common practice; but both the body of the place and the ravelins have a greater command over the glacis and covered way, than is usually given by the most approved writers on Fortification.

My reasons, for departing from the common dimensions, and adopting a bolder relief, as being much stronger, shall be explained hereafter.

CHAP. VII.

OF THE COMMUNICATIONS BETWEEN THE VARIOUS PARTS OF A FORTRESS.—THE NATURE OF RAMPS, GATES, SALLYPORTS, BRIDGES, DRAWBRIDGES, CAPONIERS, STAIRCASES OF COMMUNICATION, BARRIERS, BATARDEAUS, AND CUNETTES, EXPLAINED.—GENERAL REMARKS ON DRY AND WET DITCHES.

I shall now explain to you those details respecting a regular fortress, before alluded to, which could not have been introduced in treating of the general plan or profile, without the risk of creating confusion.

The ramparts of a regular fortress being raised much higher than the natural level of the ground, and the interior slope being too steep for men to march upon; it is necessary to have sloping roads made at various parts, in order to afford a convenient ascent for troops and guns.

In Fortification, any road of this kind rising in an inclined plane is called A RAMP.

The body of the place communicates with the outworks and covered way by means of gates and bridges.

The GATES OF THE BODY OF THE PLACE, which in a fortified city are called the TOWN GATES, are usually placed in the middle of the curtains, and they are arched over in a substantial manner.

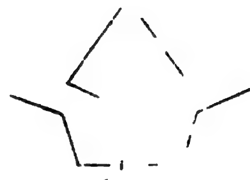
The GATES OF OUTWORKS are also usually arched over, except when the work is very low. In that case they may be left open at top.

Guard rooms are generally built close to all the gates of the body of the place; and near every other gate of importance.

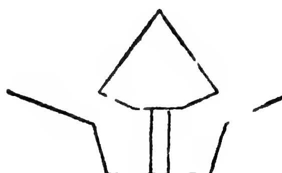
I shall now show you the manner, in which THE BRIDGES OF A FORTIFIED PLACE are usually represented, in a plan.

Draw a front of fortification with a ravelin before it.

Mark* two points near the center of the curtain, and equally distant from it, to represent the position of the gate.



From these points, draw two perpendiculars, extending from the curtain to the gorge of the ravelin.

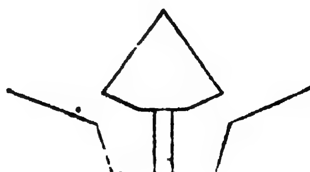


These two last drawn lines will represent the sides of the bridge.

In each of the bridges of a fortress, there is usually a drawbridge; that is to say, a part moving upon pivots, which can be drawn up or let down at will. When it is drawn up, the communication is stopped.

THE DRAWBRIDGE is always placed close to the gate.

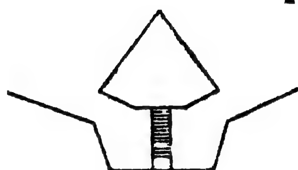
Mark off a small portion of the bridge, in the form of a square nearly, by drawing a line perpendicularly across it, near the curtain.



The square portion of the bridge, thus marked off, is to represent the drawbridge. The remainder of it, no part of which is moveable, is called THE STANDING PART OF THE BRIDGE.

The drawbridges of a fortress are always of wood; and the standing parts are also usually formed of wood. A number of small perpendiculars are therefore drawn across the standing part of the bridge, to denote that it is covered with planks.

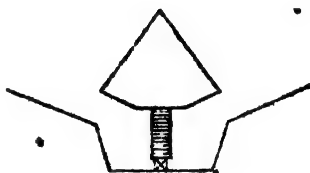
Draw small perpendiculars accordingly.



Two diagonals are usually drawn across that part of the figure, which is to represent the drawbridge; and this part is made narrower than the rest of the bridge.

Rub out the two sides of your drawbridge; and make it a little narrower.

Then draw diagonals connecting the opposite angles of it.



The bridge and drawbridge are now complete, according to the manner in which they are usually represented, in plans of fortification drawn on a small scale.

When plans are drawn on a larger scale, it is usual to draw double lines on each side of the bridge, in order to represent the width of the railing; and the ends of piers or beams, projecting beyond the sides of the bridge at certain intervals, are also sometimes represented by small rectangles.

When any bridge of a fortress is very long, it may sometimes have two drawbridges instead of one. They are of course placed at some distance from each other; but one of them is always close to the gate, as was before observed.

The tenail has been left out in our present figure, for the sake of clearness; but if there were a work of this kind in front of the curtain, there would then be two bridges required in place of one: the first bridge to extend from the curtain to the tenail; the second from the tenail to the ravelin

The gate of the ravelin is made in one of the faces, usually about the center of the face, from whence there is a direct communication to the covered way, by a bridge with a drawbridge similar to that of the body of the place.*

The principal gates of a fortress, with the bridges leading from them towards the country, are made spacious and convenient for the passage of carriages; but even in a very large fortress, if the ditches are dry, there are not usually above two or three great communications of this nature.

In the remaining fronts, there are smaller gateways intended for infantry only, which lead by a sloping descent down to the bottom of the dry ditch.

These are called POSTERNS OR SALLYPORTS.

In those fronts, where there are no bridges, you ascend from the dry ditch into the outworks and covered way, by means of STAIRCASES OF COMMUNICATION.

* Sometimes the communication is made near the inward extremity of the face of the ravelin; and this method may, in some respects, be considered preferable to the former.

There is usually, for instance, a staircase in the reverse of the tenail; also in the gorge of the ravelin.

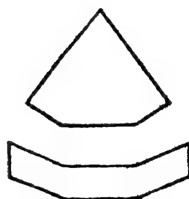
The staircases for ascending into the covered way are placed, one at each of the salients, and one at each of the reentering angles, of the counterscarp.

Consequently every salient and every reentering place of arms has its staircase.

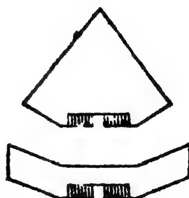
These staircases are usually made double, that is to say with two flights of steps, one branching to the right and the other to the left.

We shall now proceed to draw some staircases, in the manner in which they are represented, in plans done on a small scale.

Rub out your front of fortification, as also the bridge and drawbridge, represented in your figure, leaving only the ravelin, in rear of which draw a tenail.



Draw a double staircase in rear of the tenail. Draw also a double staircase in the middle of the gorge of your ravelin.

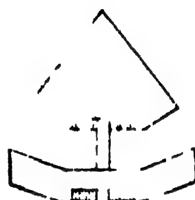


When the fortress has dry ditches, there are usually works called CAPONIERS, in each front where there are no bridges.

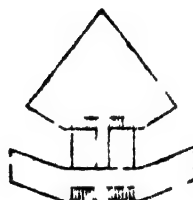
A caponier consists of a direct road or communication across the ditch, with parapets on each side to cover it, which are, of course, raised higher than the general level of the ditch. These

parapets are like that of the covered way, for they slope off outwards to the right and left, until they sink gradually down to the level of the bottom of the ditch; so that each of them forms a small glacis.

Draw two perpendiculars from the middle of your tenail towards the gorge of the ravelin, at a certain distance from each other, in order to represent the crests of the two opposite parapets of the caponier.

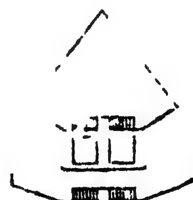


Parallel to the last drawn lines, draw two new lines outwards, to the right and left, to show the extent of the two small glacis of your caponier.



The parapets and glacis of a caponier are not usually continued quite close to the tenail and ravelin, but more commonly terminate at a sufficient distance from each, in order to afford convenient communications with the other parts of the main ditch.

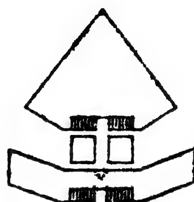
Draw lines across the glacis of your caponier, parallel to the curtain of the tenail and gorge of the ravelin, in order to show the breadth of the said communications, and at the same time to represent the proper extremities of your caponier.



Sometimes the caponier communicates with the main ditch at one extremity only; namely, that which is most advanced towards the country.

Gateways or sallyports, covered at top, are usually dotted in the plan of a work, and when they are arched, dotted diagonals are also sometimes drawn to connect the opposite angles of their extremities.

Represent, by dotted lines and diagonals, an arched sallyport under your tenail



In your present figure, the various communications used in a dry ditch are now represented. There is a sallyport under the tenail, a caponier across the ditch between the tenail and ravelin; communications to the right and left from each extremity of the caponier to other parts of the main ditch; and staircases to ascend from the level of the ditch into the interior of the tenail and ravelin.

In order that you may understand the nature of a caponier more clearly, we shall next proceed to draw the section of one.

Draw a right line, to represent the general level of the main ditch in front of the tenail.

Mark two points on it at a convenient distance, and from thence raise perpendiculars of equal lengths, to show the height of the two parapets of a caponier.



From the foot of each perpendicular, set off a certain distance, inwards, to represent the base of the interior slope of these parapets; and draw the said interior slopes.



Upon the ground line, outwards, mark points on each side, at an equal distance, to show the foot of the small glacis of the caponier.

Draw the slopes of these glacis, directing them from the crest of each parapet, upon the two last-marked points.



Sometimes the caponier has banquettes in rear of its parapets.

Draw banquettes in rear of each parapet of your caponier, in the usual manner.



Rub out superfluous lines, and the section of a caponier will be complete.



The parapets of a caponier are intended to protect troops crossing the ditch, against the enemy's fire.

In passing across the ditch of a ravelin, the enemy's fire can annoy you in one direction only. Therefore a half caponier, or, in other words, a communication constructed with one parapet and glacis only, is quite sufficient for the ditch of the ravelin.

Rub out one half of your caponier.



The figure which now remains represents A HALF CAPONIER, OR DEMICAPONIER, as it is also called.

It was before explained, that even in a large fortress, there are usually only two or three principal gates and bridges, leading from the body of the place and outworks to the covered way.

In these particular parts, there are spacious roads from the covered way to the country, which of course cut deep into the glacis and right across it, otherwise they would not be convenient for carriages.

In other parts, the covered way communicates with the glacis by means of short ramps, which signify sloping roads, as was before explained.

THE RAMPS OF THE COVERED WAY usually proceed from the faces of the reentering places of arms.

In all parts, where the line of palisading in the covered way is intersected by these ramps, there are usually spar gates erected, which when shut have the same appearance nearly as the palisades themselves.

These gates are called THE BARRIERS OF THE COVERED WAY.

It may here be observed, that the other gates, before mentioned, named barriers of the traverses, which are also erected in the covered way, are constructed in the same manner, as those which have just been described.

When the ditches of a fortress are always full of water, a great number of bridges of communication are of course necessary. Those which lead from the principal gateways to the high roads are made wide and strong, in order to afford a convenient passage for heavy carriages; but those, which lead from the sallyports,

serve merely for the use of the troops, are made narrower and less substantial.

Boats are also used for the passage of troops across wet ditches, partly to save expense, and partly from necessity, because towards the close of a siege, the bridges are rendered unserviceable by the enemy's fire. These boats are usually kept behind the tenails, where they are not much exposed; and sometimes small basons are made in the gorge of the ravelins to receive and screen them from cannon shot.

In that case the form of the ravelin will be as follows.



Sometimes, when a fortress is situated near the sea, or on the banks of a river, the ditches are constructed in such a manner, that they may either be kept dry or inundated at pleasure.

In order to derive the greatest possible benefit from this expedient, it is usual to have several dams with sluices built across the ditch at various parts; by means of which the water may be let into any particular portion of the ditch, that you think proper, whilst the rest of it may be kept dry.

A dam constructed across any ditch of a fortress, for the above purpose, is called A BATARDEAU.

A batardeau is a solid wall of more than sufficient strength to resist the greatest pressure of water that may act upon it; and in order that it may not afford a convenient passage, across the ditch, to an enemy attempting to surprise or assault the fortress,

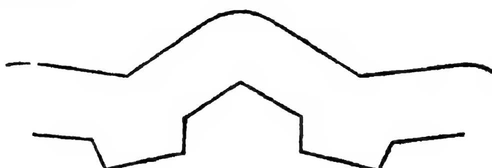
the top of it is built with a ridge, like that of a steep roof. Consequently the section of it is as follows.



The batardeaus of the main ditch may either be constructed before the point of a bastion, in the prolongation of the capital; or they may be placed in front of, and perpendicular to, a curtain.

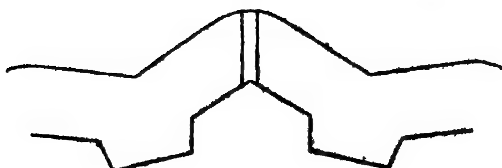
I shall now show you the method of drawing a batardeau, which we shall suppose to be placed before a bastion.

Draw two fronts of fortification with a counterscarp, but without tenails or ravelins.

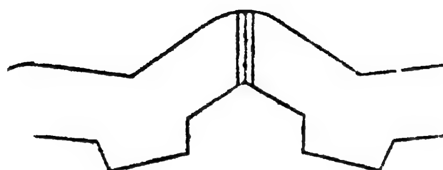


Draw two lines across the ditch of the center bastion of your figure, at equal distances from the point of the bastion, and parallel to the produced capital.

These lines will represent the sides of a batardeau.

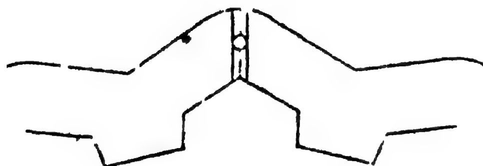


Draw a third line, also across the ditch, half way between the two former and parallel to them, which will of course agree with the produced capital of the bastion. This line will represent the ridge of the batardeau.



To increase the difficulty of penetrating into the fortress over the batardeau, it is usual to build a small round tower or turret over the middle of it, which being raised higher than the rest of the batardeau, and pointed or shaped like a cone at top, presents an additional obstacle to an enemy.

Represent the TURRET OF THE BATARDEAU, by a small circle, and rub out that part of the ridge, which will become superfluous, after the turret is drawn.



Your batardeau is now complete. It divides the ditch of your figure into two parts, one of which may be filled with water, whilst the other is dry.

In ditches of this kind, it is of great importance to secure the sluices from the risk of being destroyed by an enemy's fire.

Sometimes the sluices are placed in the batardeau itself, grooves or openings being left in the masonry for the purpose of receiving them.

Sometimes they are placed in the interior of a bastion, with channels of communication for the water, extending from them to the main ditch on each side.

In this case, the batardeau is built quite solid across the main ditch, in front of the point of the bastion.

When the ditches of a fortress may be inundated at pleasure, the bottom of them, after the water is let out, must necessarily be marshy, as it is much lower than the common level of high water. It is therefore usual to have a narrow moat in the center of a ditch of this description, to drain off the superfluous water.

A moat of this kind in the middle of a ditch is called A CUNETTE. As it is not excavated with a view to defence, but for the sake of health and cleanliness, the depth and breadth of it are of little importance.

GENERAL REMARKS.

Ditches which may be kept dry or inundated at pleasure, are the best; and next to these dry ditches, provided that the revetments are strong, and of a sufficient height. Wet ditches are the worst of all, when the works of a fortress are strong, well reveted, and of a good profile. But if the works are very weak, or merely consist of earthen ramparts without revetments, then wet ditches are the best; for nothing else can secure such works against a general assault.

The great objection to wet ditches is the expense of bridges,

and the difficulty of preserving them. Towards the close of a siege they are often destroyed, as was before observed; and boats afford a very precarious communication, liable to interruption and delays. Consequently it becomes difficult, sometimes impossible, to support the troops in the outworks or covered way when attacked, by sending fresh men to their assistance, so that these works cannot, by any means, make such a vigorous defence, as might be done if the ditches were dry.

The various methods, which may be followed, in constructing the gates, sallyports, bridges and drawbridges of a fortress, as also the construction of batardeaus, &c. form a part of Practical not of Elementary Fortification. No detailed plans or sections of them shall therefore be attempted in the present work.

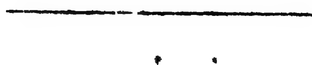
The nature of ramps shall, however, be fully explained, as they often form a very conspicuous part of the general plan of works of fortification, which cannot be clearly understood without them.

CHAP. VIII.

OF THE CONSTRUCTION OF RAMPS, AND STAIRCASES.

I shall now teach you the method of drawing the plan of a ramp.

Draw a right line to represent any part of the scarp line of the body of the place, as shown in the plan of a fortress.

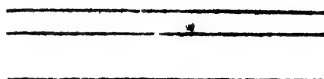


Draw a second line in rear of, and parallel to it, at any convenient distance, to represent the crest of the parapet.

The space, comprehended between these two lines, will represent the thickness of the parapet at its base.

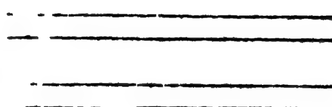


Draw a third parallel in rear of the last, to represent the back of the terreplein, or the top of the interior slope of the rampart.



The space, comprehended between this and the second line, will represent the breadth of the terreplein.

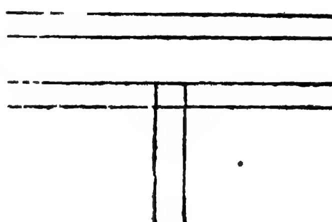
Draw a fourth parallel, also in rear of the former, to represent the foot of the interior slope of the rampart.



The space, comprehended between the two last drawn lines, will of course, represent the said interior slope.

We shall now proceed to draw our ramp, as proposed.

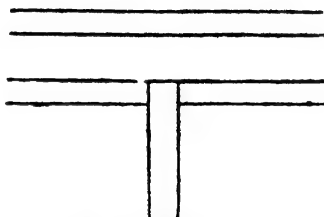
Mark two points on the back of the terreplein, at such a distance apart as you may judge convenient, for the breadth of your ramp; and from these points draw perpendiculars backwards, or towards the interior of the fortress, to represent the sides of your ramp.



It was before stated that a ramp is a sloping road, which gradually rises till it becomes as high as the terreplein.

The length of the sides of the ramp will therefore depend upon

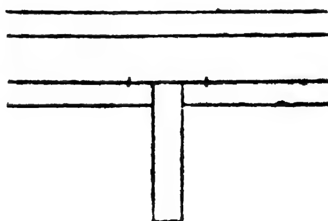
the height of the terreplein above the natural level of the ground. For instance if the terreplein were 18 feet high, and if you thought it convenient to give the ramp a slope of 6 feet to 1; then the length of the ramp or of the two perpendiculars, which you have just drawn, would require to be 108 feet, this being six times 18.



Connect the extremities of the last drawn perpendiculars by a right line, which will show the bottom of the ramp; and rub out that part of the foot of the interior slope of the rampart, which intersects the ramp, as it will now become a superfluous line.

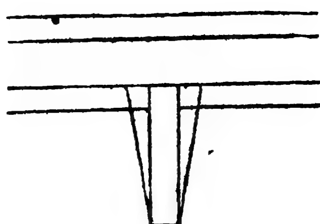
Ramps being usually constructed of earth or rubbish, it must be evident, that the sides of them will not stand perpendicularly, unless reveted. But the sides of ramps are very seldom reveted; and therefore it becomes necessary to give them a slope.

The ramp being equal in height to the terreplein, at top, must of course have a slope there, on each side, equal to the interior slope of the rampart.



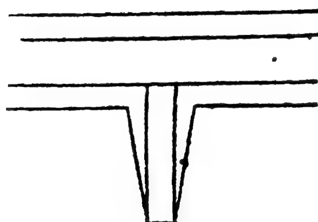
From the top of each side of the ramp, you will therefore mark points to the right and left, at a distance equal to the breadth or base of the interior slope of the rampart.

The bottom of the ramp, being on the same level with the natural ground, can have no slope. The slope of each side of the ramp, which is considerable at top, will therefore gradually fall away to nothing, at bottom.

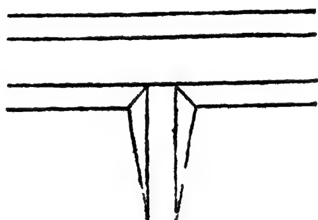


From those points, which represent the extent of the slope of the two sides of the ramp at top, you will therefore draw oblique lines to the foot of the ramp.

The triangular space, comprehended between either of these oblique lines and the adjoining side of the ramp, represents the slope of that side of the ramp, which, as I said before, is considerable near the top, but from thence falls away to nothing at bottom.



Rub out those parts of the interior slope of the rampart, and of the slopes of the ramp, which intersect each other.



Join the opposite angles where the interior slope of the rampart, and the two sloping sides of the ramp meet each other, by short diagonal lines.

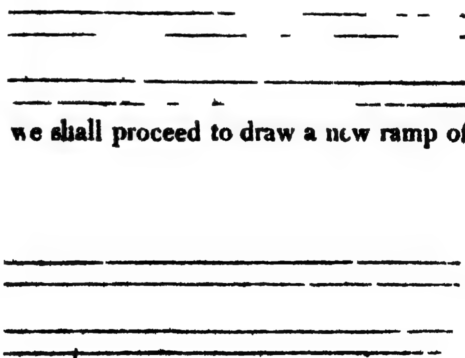
These diagonals represent furrows or hollows formed by the meeting of the above slopes; for in all cases, whenever two oblique or sloping planes meet each other, either a ridge or a furrow must be formed by their junction, as may be observed in the roofs of houses.

The plan of A PERPENDICULAR RAMP, that is to say of a ramp laid out perpendicularly to the general line of the rampart, is now complete.

Sometimes the short lines which represent the top and bottom of the ramp are rubbed out in a finished drawing but it is more correct to show them, because the terreplein, the ramp, and the natural level of the ground being all on different planes, ridges or furrows must necessarily be formed where they meet each other Accordingly there is a small ridge at the top of the ramp, and a small furrow at the bottom of it.

In fortified places, there are usually buildings behind the ramparts and near to them, so that a ramp could not conveniently be constructed in the manner represented in our present figure, as it would project too far towards the rear, and might therefore interfere with the streets or houses.

For this reason, ramps are seldom or never made perpendicular to the ramparts of a fortress, in the manner just explained, but oblique to them, and as nearly parallel to them as possible



Rub out your present ramp, and restore your figure to its original state, which being done, we shall proceed to draw a new ramp of a more convenient form.

Upon the foot of the interior slope of your rampart, mark a point for the bottom of your proposed ramp.

Take in your compasses the proposed length of your ramp, which, as I said before, will depend upon the height of the terreplein; and with this distance, as a radius, from the above point as a center, make an intersection on the back of the terreplein.

Connect these two points by an oblique line, which will represent one side of your proposed ramp.

This shall be called THE EXTERIOR SIDE OF THE RAMP, as it is supposed to be more advanced towards the country, than the other side, which remains to be drawn, will be.

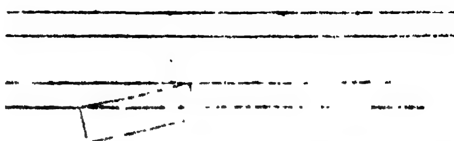
From the extremities of the exterior side of your ramp, draw perpendiculars backwards or towards the interior of the work, in order to show THE TOP AND BOTTOM OF THE RAMP.

Connect these two perpendiculars by a right line, which will represent THE INTERIOR SIDE OF THE RAMP.

The interior side of the ramp being, at top, on the same level

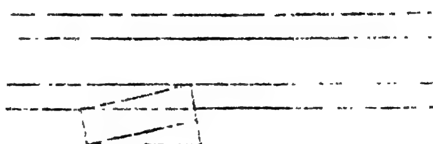
with the terreplein, must have a slope, there, equal to the interior slope of the rampart.

Produce backwards that perpendicular, which represents the top of the ramp, and make the produced part equal to the breadth of the interior slope of the rampart.



This produced line will represent the extent of the slope of the interior side of the ramp, at top.

From the extremity of the produced line, draw an oblique line to the foot of the interior side of the ramp.

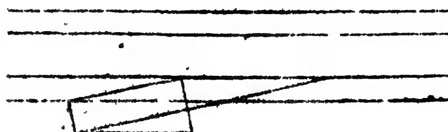


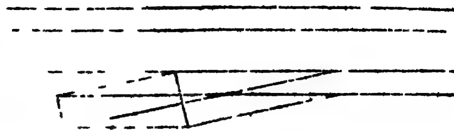
The triangular space, thereby formed, will represent THE SLOPE OF THE INTERIOR SIDE OF THE RAMP, which is considerable at top, but from thence falls away to nothing at bottom.

The upper part of the ramp is not yet complete, for it must of course be continued, until it meets the back of the terreplein.

This may be done by producing it, either in the same direction, so as to form one continued right line, or not, as you think proper. We shall use the former method.

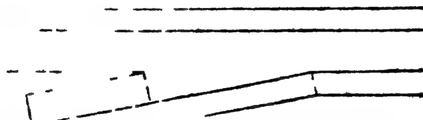
Produce the interior side of your ramp, until it meets the terreplein.





At a distance equal to the breadth of the interior slope of the rampart, draw a right line in rear of, and parallel to, the last-drawn line, in order to show the slope of that part of the interior side of your ramp, which remained unfinished.

Connect the angles, formed by the meeting of the said slope, and the interior slope of the rampart, by a right line, in order to shew a furrow which will be formed there.

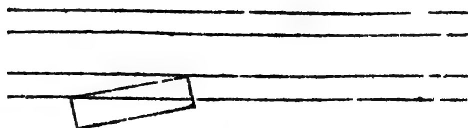


Then rub out superfluous lines, and your ramp will be complete.

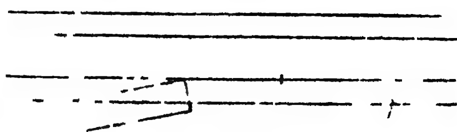
Your figure, in its present state, represents AN OBLIQUE RAMP, such as is almost always used in fortresses. It affords a convenient passage for troops and guns, and at the same time takes up very little room towards the rear.

The direct ramp, which you before drew, is seldom or never used except in works where the terreplein is very low, such as field works, for instance.

Sometimes A DOUBLE RAMP is made, which consists of two ramps, constructed in contrary directions to each other, nearly meeting at top.

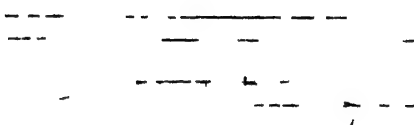


Rub out every part of your present ramp excepting the two sides of it, and those perpendiculars which represent the top and bottom of it; and restore the original form of your rampart.

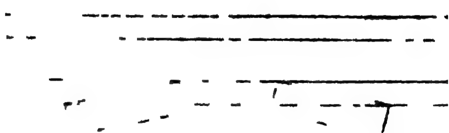


At any convenient distance from the top of your ramp, mark a point on the back of the terreplein, to represent the top of a second ramp, which is to be similar to the former, but constructed in a contrary direction.

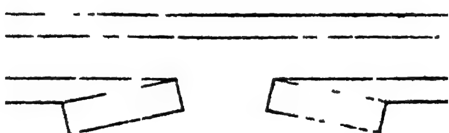
And from this point, as a center, with a radius equal to the length of your first ramp, make an intersection on the foot of the interior slope of the rampart.



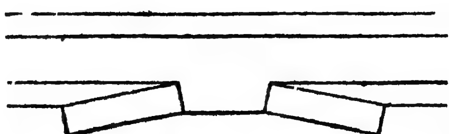
Join these two points by a right line, which will represent the exterior side of your second ramp.



Draw the top and bottom, and the interior side of your second ramp, making it equal to the first in all these dimensions.



Rub out that part of the back of the terreplein, which extends between the two ramps: rub out also that part of the foot of the interior slope of the rampart, which intersects them.

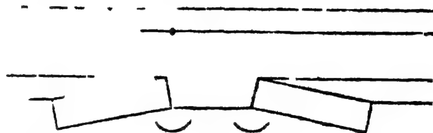


Connect the upper extremities of the interior sides of your two ramps by a right line; in order to show the new form, which must be given to the back of the terreplein, in consequence of the formation of the double ramp.

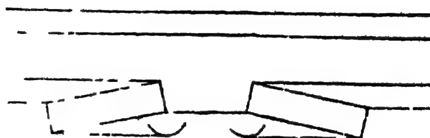
Then if you suppose the greatest slope of the interior sides of your double ramp to be equal to the interior slope of the rampart, which is usually the case in practice:

Connect the lower extremities of the interior sides of your two ramps by a right line; and your double ramp will be complete (*See the fourth of the following figures*).

But if the greatest slope of your proposed double ramp is supposed to be either greater or less than the interior slope of the rampart, then the rule for finishing it would be as follows.



From the top of the interior side of each of your ramps, as a center, with a radius equal to the greatest supposed breadth of the interior slope of the ramp, as a radius, describe arcs.



From the bottom of each interior side draw a tangent to the nearest arc.



Draw another line, connecting the two arcs, which must also be a tangent to them, and produce it till it meets the two former tangents.

The three tangents, drawn under the above supposition, must at their junction form angles, and consequently ridges or furrows, which, strictly speaking, ought to be represented by right lines in the plan; but if, by reason of the great obtuseness of the said angles, the tangents should have the appearance of one continued right line nearly; then, it would not be worth while to draw any lines for the above-mentioned purpose.

Rub out your arcs: draw right lines across your slope to represent ridges or furrows, if you think it necessary; and your double ramp will be complete.

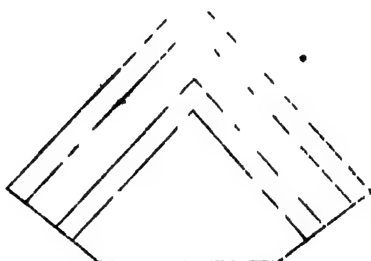
You may here observe, that the interior slope of your double ramp is considerable, between and opposite to the tops of the two ramps, from whence it falls away to nothing at the bottom of each.

Double ramps are always the most convenient.

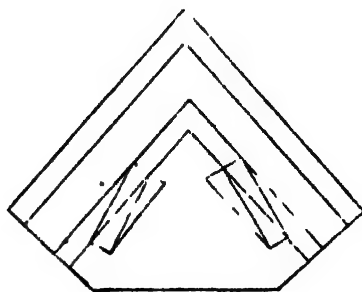
When ramps are made behind the faces of any work, they generally meet at top or nearly so, and form a double ramp in rear of the salient angle.

In this case the meeting of the two ramps is often made circular.

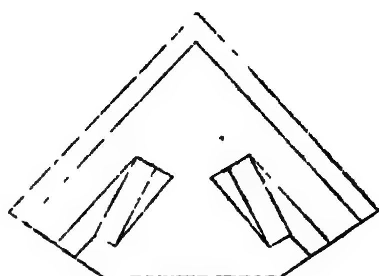
Draw a work with two faces, to represent a ravelin, marking the parapet, terreplein, and interior slope of the rampart.



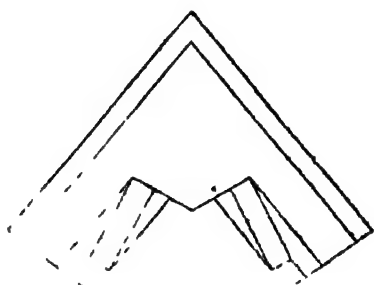
Draw two ramps, one on each face, at an equal distance from the angle; representing the slopes of their interior sides by triangles, as before explained, but without forming any communication from the top of them to the terreplein.



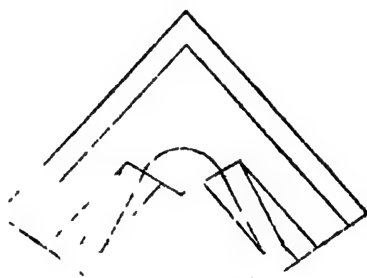
Rub out those lines of the interior slope of the rampart, which either intersect your two ramps, or are continued beyond the top of each.



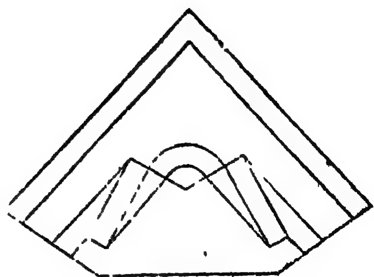
Produce those perpendiculars, which represent the top of each ramp, backwards, until they meet.



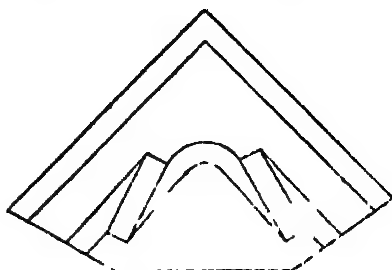
From their point of intersection, as a center, describe an arc connecting the tops of the interior sides of your two ramps.



From the same center, describe a second arc connecting the adjoining extremities of the two oblique lines, that were drawn to represent the bottom of the slope of the interior sides of your ramps.



This being done, rub out superfluous lines, and the figure of your double ramp will be complete.



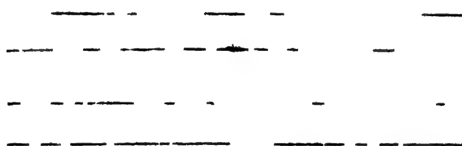
Sometimes double ramps of this kind are so constructed, that the extremities of the oblique lines, which represent the bottom of the slopes of their interior sides, may meet in the same point. In this case the second arc would be superfluous.

This would take place if the two ramps, represented in our present figure, had been placed a little nearer to each other at top.

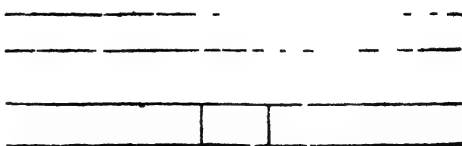
Sometimes, in lieu of ramps, staircases are constructed for ascending the terreplein of works, but these staircases are only fit for troops, not for guns or carriages.

They are drawn as follows.

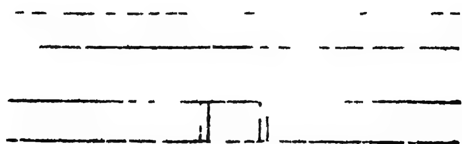
Draw four lines parallel to each other, to represent the parapet, terreplein, and interior slope of the rampart of any work.



Draw two lines perpendicularly across the interior slope, to represent the total width of a staircase.



Draw two other lines, inwards, near to these, and parallel to them.



Between the two last drawn lines, draw lines perpendicular to them, at any convenient distance apart, to represent steps: and the plan of A STAIRCASE OF THE RAMPART will be complete.

The spaces to the right and left of the steps, which are comprehended between each pair of perpendiculars, represent the copings or low parapet walls, which are usually constructed in staircases of this description.

Staircases even for troops are not of such permanent utility as ramps, because they are liable to be destroyed by shells; whereas ramps when injured may easily be repaired.

The STAIRCASES OF COMMUNICATION, in the reverse of the tenail or ravelin, which you before drew on a small scale, are drawn according to the same rule as a ramp nearly, when they are represented on a larger scale, such as is capable of showing the slopes of the revetment.

To explain this, we shall draw the plan of a double staircase, in the manner alluded to.

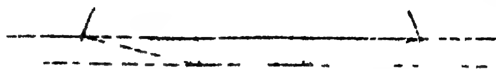
Draw two lines parallel to each other to represent part of the reverse of a tenail or gorge of a ravelin: and let the distance between these two parallels show the slope of the revetment.

It will be evident that the side of any staircase following the general line of a sloping revetment, must also itself have a gradual slope from bottom to top.

Mark points on the lower line, which represents the foot of the slope of the revetment, in order to show the breadth of a landing place at the bottom of your proposed double staircase.

From each of these points, as a center, with a radius equal to the length of your proposed staircase, describe arcs intersecting the top of the slope of the revetment.

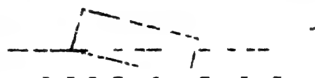
Connect these points of intersection to the former points by right lines, which will represent THE INTERIOR SIDES OF THE DOUBLE STAIRCASE, commencing from the foot of the slope of the revetment and gradually rising to the top of it.



Set off perpendiculars from each extremity of the last-drawn lines, outwards, to represent THE TOP AND BOTTOM OF THE DOUBLE STAIRCASE.

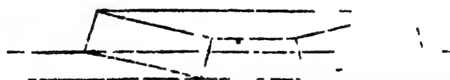
Let these perpendiculars be equal to each other, their length representing the breadth of the staircase:

And connect the extremities of them by right lines, which will represent THE EXTERIOR SIDES OF THE DOUBLE STAIRCASE.



The exterior sides of your double staircase must necessarily be reveted; and in order that the stairs may be everywhere of the same breadth, this revetment must of course have a slope equal to the slope of the original revetment of the work.

Connect the bottom of each exterior side by a right line, which will represent the bottom of the revetment of your double staircase: and connect the top of each exterior side by a right line, which will represent the top of the said revetment.



The space, bounded by the two last drawn lines and the exterior sides, represents THE SLOPE OF THE REVETMENT OF THE EXTERIOR SIDE OF THE STAIRCASE.

Rub out superfluous lines.

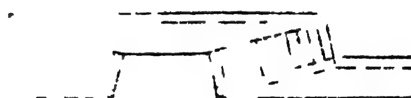


Your staircase in its present form resembles a double ramp, and is constructed exactly on the same principle, but with this difference, that the ramp is constructed in rear of the foot of the interior slope of the rampart, in order that it may not cut into and diminish the breadth of the terreplein; whereas the staircase here represented is constructed in front of the slope of the revetment, and therefore does cut into the interior of the work.

Draw perpendiculars to show the steps and your double staircase will be complete,* an open space, or A LANDING PLACE, being represented at bottom.

The interior side of a staircase may sometimes have A COPING or low parapet wall, and the revetments may also have copings, which are sometimes represented in plans drawn on a large scale.

In that case your figure would require to be altered as follows.



* Properly speaking, the sides of each staircase, in a large finished plan, ought not to be represented by right lines, but by lines so drawn as to have the appearance of steps, forming a kind of distorted section of the staircase. The reason of this will be explained in Chap. XI.; but it is scarcely ever worth while to mark such very minute details in plan-drawing. It is proper, however, that they should be understood.

CHAP. IX.

OF BATTERIES.

The guns and mortars, used in the defence of a fortress, are placed on the terrepleins of the various works in rear of the parapet, as was before observed.

Wherever guns are placed, openings must be cut across the upper part of the parapet, for them to fire through, which are called embrasures.

In those portions of the ramparts of a fortress, which are fitted up as GUN BATTERIES, the parapet has no banquette behind it.

MORTAR BATTERIES do not require any embrasures, but consist of a simple parapet only. The reason is, that mortars do not fire at any object in a direct line, or nearly so; but pitch their shells over the parapet, at a considerable elevation.

Batteries, thrown up in the field, do not differ materially from those which are constructed on the ramparts of a fortress.

We shall therefore proceed to draw the sketch of a field battery; having done which, you will find no difficulty in understanding the nature of the batteries of a fortress. We shall begin with the profile or section.

The section of a field battery is exactly like that of a traverse, which you before drew, only that it has no banquette.

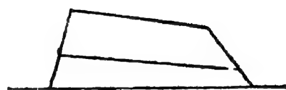
Draw a ground line, upon which construct the section of a simple parapet having an interior, a superior, and an exterior slope.



The figure, in its present state, represents the section of a mortar battery.

It also represents a section of the solid part of a gun battery: but if the section were supposed to be taken through AN EMBRASURE, the opening would, of course, require to be shown.

This is done as follows.



Mark a point on the interior slope, about one third way up; and from this point, draw a right line across your parapet, in a direction nearly parallel to the superior slope.

The line which you have just drawn divides the parapet into two parts. The under part is supposed to be solid. The upper part is supposed to be hollow, and forms the embrasure.

In a section drawn through an embrasure, the solid part only of the parapet is seen in section, the upper part is of course supposed to be seen in elevation.

The bottom of an embrasure is called THE SOLE OF THE EMBRASURE, and in the section it is represented by the line that you drew last.

The sides of an embrasure are called THE CHEEKS OF THE EMBRASURE.

When a battery is made for two or more guns, so that there are several embrasures or openings in the parapet; each of those

solid portions of it, which lie between any two embrasures, is called A MERLON.

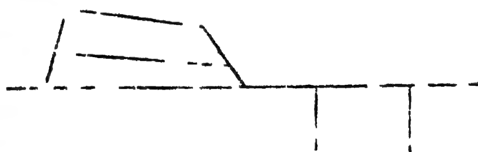
But those two solid portions of the parapet which are at the right and left extremities of the battery, adjoining to the first and last embrasures, are called HALF MERLONS, from the dimensions usually given to them.

That part of the parapet of a gun battery, which is below the level of the embrasures and merlons, is called THE SOLID, on account of its being solid throughout its whole extent.

In erecting a field battery, such as that of which you have now drawn the section, the earth for forming the parapet is obtained from a ditch excavated in front of it.

A berm is always left between the foot of the exterior slope of the parapet, and the ditch of the battery.

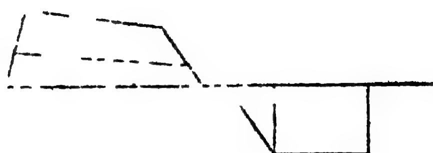
THE DITCH OF A BATTERY is, in the first instance, usually cut perpendicular: afterwards slopes are formed. The sides of it are called the reverse and front sides of the ditch, instead of using the terms "scarp and counterscarp," which do not apply to such a small work as a field battery.



In front of the parapet of your battery, mark two points on the ground line, at a convenient distance, to represent the breadth of the ditch. From thence drop perpendiculars equal in length to show its depth; and draw the bottom of the ditch by joining the lower extremities of these perpendiculars.

The section of the ditch of your battery is now represented by a rectangle, which shows the form of it before the slopes are drawn.

Draw an oblique line to show THE REVERSE SLOPE OF THE DITCH OF THE BATTERY, leaving a sufficient berm between it and the foot of the exterior slope of the parapet.



Draw another oblique line to show THE FRONT SLOPE OF THE DITCH OF THE BATTERY.

Rub out those two perpendiculars which showed the original form of the sides of the ditch, before the slopes were drawn.

And dot those parts of your ground line, which would become superfluous in a finished section.



In small field works, such as a battery, the bottom of a ditch is sometimes called THE SOLE OF THE DITCH.

The only thing, which is now wanting to complete the section of your gun battery, is the platform.

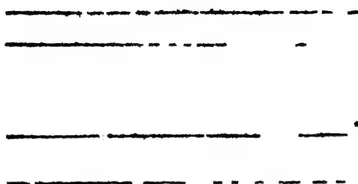
Before I proceed to explain the nature of platforms, I shall first teach you the method of drawing the plan of a gun battery.

The plan of a simple parapet without embrasures must first be represented.

This will consist of four lines parallel to each other at proper distances, the three spaces, comprehended between which, will

represent the interior, the superior, and the exterior slopes of the parapet.

Draw four lines accordingly, placing the interior slope towards the bottom of your paper.



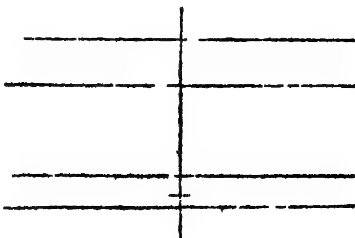
Draw a line perpendicularly across the center of your figure, to represent the direction of the object against which the battery is supposed to be constructed.



This line is called THE LINE OF FIRE, OR OBJECT LINE of the battery. The center of your embrasure ought to agree with it.

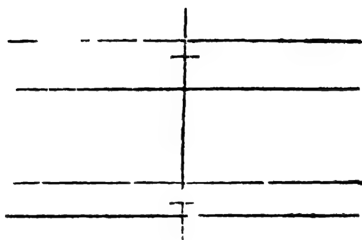
On referring to your section, you will perceive that the rear of the embrasure commences about one third way up the interior slope of the parapet, therefore it cannot agree exactly with either of those lines in the plan, which represent the bottom or the crest of it It must consequently be placed between the two, but nearer to the former line.

Mark a point on the line of fire to represent the rear of your embrasure, placing it about one third way up that space which represents the interior slope of the parapet.

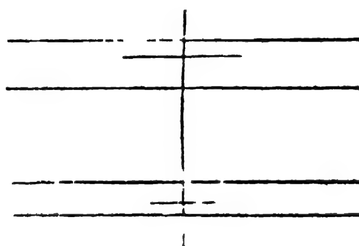


In like manner, by referring to your section, you will find that the front of your embrasure does not exactly agree either with the top or bottom of the exterior slope of the parapet, but stands about one third or one fourth way up that slope.

You will therefore mark a second point on the line of fire, to show the front of the embrasure, upon that space which represents the exterior slope of the parapet, but nearer to the foot than to the crest of the said slope.



Through these points, draw lines perpendicular to the line of fire and intersecting it, making the most advanced perpendicular the longest.

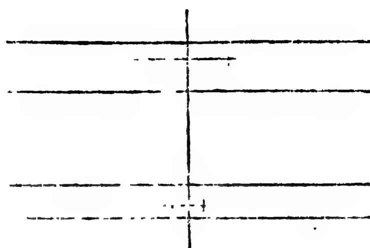


Upon the rear perpendicular, on each side of the line of fire, mark points at a distance rather less than the base or breadth of the interior slope of the parapet.

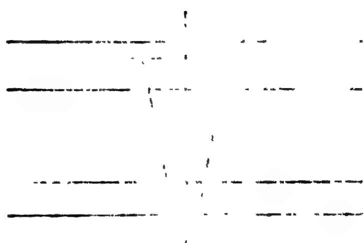
The space comprehended between these two points is to show the width of the embrasure in rear.

On each side of the line of fire, set off upon the front perpendicular, a distance rather less than the base or breadth of the exterior slope of the parapet.

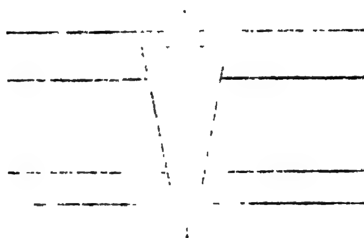
The space, comprehended between the two last marked points, is to show the width of the embrasure in front.



Connect these points by right lines, and the form of the sole or bottom of the embrasure will be complete.



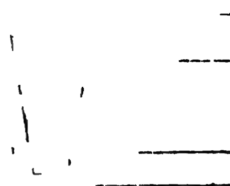
Rub out those parts of the original figure, which will become superfluous after the sole of the embrasure is drawn; excepting your line of fire, which you will dot.



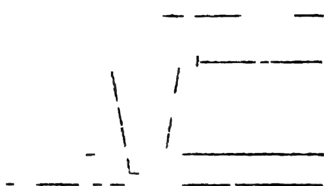
The rear line of the sole of an embrasure, that is to say the shortest of your two perpendiculars, is called THE SILL OF THE EMBRASURE.

If the cheeks of the embrasure were built perpendicularly, the above would be a correct plan of it; but this is not the case. The cheeks almost always have a slope, which must next be represented.

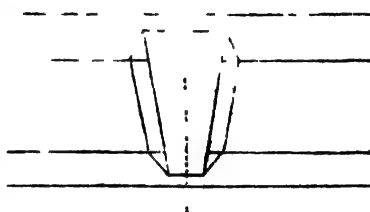
On each side of your embrasure, at a short distance from it, mark points upon the interior crest of the parapet, to represent the base of the slope of the cheeks of the embrasure at that part



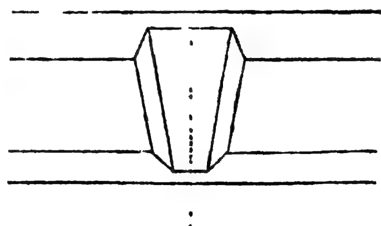
On each side of your embrasure, at a short distance from it, mark also points upon the exterior crest of the parapet, in order to show the base of the slope of the cheeks of the embrasure at that part.



On each side of the embrasure, draw right lines, connecting the above points, from which you will also draw right lines to the adjoining angles or extremities of the sole of the embrasure.



Rub out superfluous parts of your original parapet, and the plan of an embrasure for one gun is now complete, the sole of the embrasure, and THE SLOPE OF THE CHEEKS OF THE EMBRASURE being distinctly seen.



The narrow part of an embrasure, that is to say the rear of it, is called THE NECK OF THE EMBRASURE.

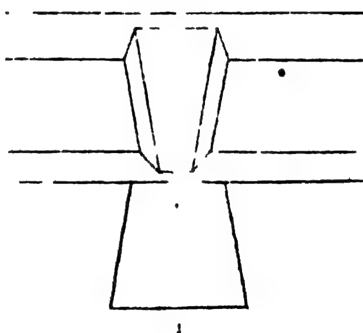
The broadest part or front of an embrasure is also called THE MOUTH OF THE EMBRASURE.

In rear of the embrasure, a platform is made for the gun to stand upon, whilst it is fired; otherwise from its great weight the wheels of the carriage would sink into the ground, and it would soon become unmanageable.

The rear or tail of THE PLATFORM is parallel to the front of the battery: the platform is broader in rear than in front, and the center of it exactly agrees with the line of fire.

Draw a platform accordingly. Let the front of it agree with the bottom of the interior slope of the parapet; and make the width of it in front equal to the width of the mouth of the embrasure nearly.

Make it wider by about one half in rear than in front; and let the length of it be rather less than the thickness of the parapet at top.



In a regular fortress, platforms are sometimes made of hard stone or of strong cement; sometimes they are made of wood. In a field battery, platforms are always made of wood.

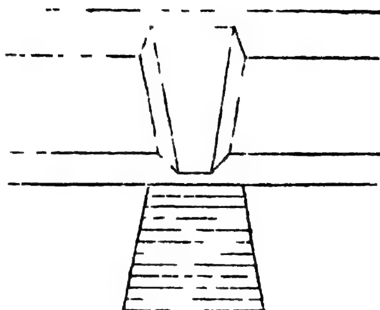
The upper part of the platform, upon which the gun moves, consists of planks, which are laid perpendicular to the line of

fire. In the front there is one piece of stout timber raised several inches higher than the planks, which is called a hurter.

The hurter strengthens the front of the platform, and may also sometimes be useful by checking the wheels of the gun carriage.

Draw parallel lines across your platform to represent a hurter and planks.

The figure, in its present state, represents the plan of a one-gun battery, complete in every respect, excepting the ditch, which is of so very simple a nature, that it was not thought necessary to introduce it, for the sake of further explanation.



The space, between the bottom of the parapet, and the nearest parallel, will of course represent THE HURTER.

THE PLANKS of a platform, like those of the floor of a house, rest upon beams of timber, to which they are spiked or screwed down; and without which, it may easily be conceived, that the platform would not be sufficiently strong.

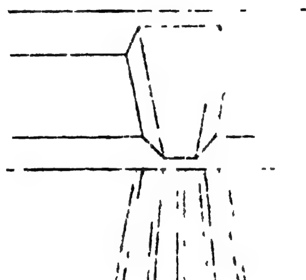
The beams, which support the planking of a gun or mortar platform, being sunk into the ground, are called sleepers.

In a gun platform five sleepers are commonly used. The middle of the center sleeper exactly agrees with the line of fire. The

two outside sleepers are placed so as nearly to agree with the two sides of the platform: consequently they are not parallel to the center sleeper, but oblique outwards from front to rear. The two remaining sleepers are placed half way between the center and the outside ones.

The whole of THE SLEEPERS extend as far as THE TAIL OF THE PLATFORM.

Rub out your platform and draw five sleepers accordingly.



Your plan, in its present state, represents a gun battery after the sleepers are laid, but before the planking is placed.

What an embrasure gains in width towards the front is called THE SPLAY OF THE EMBRASURE; and in like manner, what a gun platform gains in width towards the rear is called THE SPLAY OF THE PLATFORM.

The embrasures and platforms of a gun battery are constructed with a splay, in order that the gun may be able conveniently to traverse, or change its direction towards the right and left, and thereby command a greater scope of fire.

Gun platforms have not only a splay, but a slope, the tail of the platform being always made higher than the front of it.

To explain these particulars more fully, I shall proceed to teach you the method of drawing the section of a gun platform.

In rear of the interior slope of the parapet of the gun battery, as represented in the section which you before drew, set off a distance rather less than the thickness of the parapet at top, in order to represent the length of the platform; and from thence raise a short perpendicular to show the height of the slope of the platform, or, as it is usually called, THE RISE OF THE PLATFORM.

From the top of this perpendicular, draw an oblique line to the foot of the interior slope of the parapet.

This line will represent the top of the platform sloping upwards from front to rear.

In its present state the tail of the platform appears higher than the ground line. The earth in rear of it would therefore require to be raised, in such a manner as to give it a solid foundation or bearing.

From the top of that perpendicular, which represents the



height of the platform in rear, you will therefore draw an oblique line, backwards, to any convenient point on the ground line, in order to show the manner in which the earth in rear of the platform may be raised.

In this, and in the two following figures, given in the book, the ditch of the battery, which was represented in our last section, is omitted, for the sake of clearness.

Rub out that perpendicular, which shows the height of the platform in rear: and dot such parts of your ground line as will become superfluous, after the parapet and platform are drawn.

Draw a line, at a short distance below THE SLOPE OF THE PLATFORM, parallel to it and equal to it in length, to represent the bottom of the planks.

Draw another parallel line below the former, but at rather a greater distance, to represent the bottom of a sleeper.

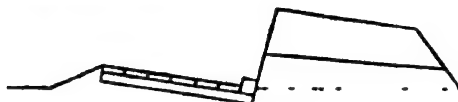
Draw short perpendiculars connecting the extremities



of these three parallel lines in front and rear, in order to show the ends of the platform.

Rub out a small part of the front of your planking in order to make room for a hurter, which is supposed to be placed there and above the front of your sleeper, draw a small square or rectangle close to the interior slope of the parapet, and higher than the planking, to represent the said hurter.

Lastly, draw small perpendiculars across that space which represents the planking, in order to show the individual planks.



The section of your battery is now complete, in which every part of the platform, namely the sleeper, planks, and hurter, are distinctly represented.

When a field battery is constructed, in the manner represented in our present figure, so that the platform is placed on the natural surface of the ground, whilst the whole of the parapet is raised above that level; it is called AN ELEVATED BATTERY.

When a field battery is raised so high, that the platforms do not stand on the natural level of the ground or nearly so, but on a terreplein elevated some feet higher; it is called A CAVALIER BATTERY.

Cavalier batteries are very seldom used on account of the great labour attending the construction of them, by reason of the boldness of their profiles; but elevated batteries are in common use.

There is another kind of field battery also very frequently used, which is called A SUNKEN BATTERY, in order to distinguish it from the former; and the construction of which is the least laborious of all.

In batteries of this description, the interior of the work is sunk, and the platforms consequently laid two or three feet below the natural ground level, whilst the upper part of the parapet only is raised above it.

Sunken batteries are not well calculated for explaining the nature of those which are constructed on the ramparts of a fortified place. We shall therefore take no further notice of them at present.

Gun platforms are constructed with a slope, in the manner represented in our figure, in order to prevent the gun carriage from recoiling or running back too far, when the gun is fired: for after the gun recoils in this manner, it must always be moved up again, close to the embrasure, before it is fired a second time. This operation, which otherwise would be very laborious on account of the weight of the gun, is rendered much easier by means of the slope.

Mortar platforms have no splay nor slope, being generally square, or at least rectangular, and laid quite level. The front of them is placed at some distance behind the parapet. They have sleepers and planks only, without any hurter. They must be made of stronger materials than gun platforms, because the recoil of mortars, when fired, acts with a considerable shock downwards, tending to break or crush the woodwork of the platform, which is not the case in the firing of guns, or at least in a very small degree.

When the plan of a battery is drawn on a very small scale, the interior and exterior slopes of the parapet are omitted, as also the slopes of the cheeks of the embrasures.

The parapet, in this case, is represented by two parallel lines only, and each embrasure by two oblique lines drawn across it, which sometimes meet in rear, forming an acute angle.

In drawing a battery on a small scale, the platforms are also omitted; but mortars are usually represented by small circles in rear of the parapet.

Draw two parallel lines to represent the front of a battery.



Represent three embrasures for guns towards the right, and four mortars towards the left, of your battery, in the manner above described.

Traverses are often made in batteries. One end of them is generally joined to the crest of the parapet.

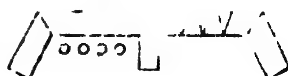
Traverses near the center of a battery are always laid out at right angles to the parapet.

Traverses, at the extremity of a battery, are generally laid out so as to form rather an obtuse angle with the face of the battery.

Draw A CENTRAL TRAVERSE between the guns and mortars in your present battery, forming a right angle with the face of your battery.

Draw two additional traverses, one at each extremity of your battery, forming an obtuse angle with the face of it.

This being done, rub out superfluous parts of your original parapet.



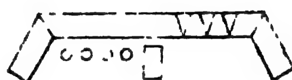
A flanking traverse, at the extremity of a battery, is called AN EPAULMENT.

The section of epaulments differs very little from that of the parapet of the face of the battery; but they are usually made rather thinner, unless they should be exposed to a direct fire. In that case they must have the same thickness as the parapet of the battery.

Epaulments must always be joined to the crest of the parapet. This is not absolutely necessary in traverses, which are sometimes separated from the parapet of the battery by a small passage.

Traverses of this kind are called DISENGAGED TRAVERSES.

Rub out the traverse, represented in your present figure, and draw a disengaged traverse in lieu of it.



Traverses joined to a parapet at one end, like your former one, are called ENGAGED OR ATTACHED TRAVERSES.

In describing a battery, when the term "traverse" simply is mentioned, without specifying particularly what kind of traverse it is; an engaged traverse, as being the most common, is always implied.

A battery, which throws its shot in a direction nearly perpendicular to the line of troops, or to the face of a work, against which it may be firing, is called A DIRECT BATTERY.

A battery, which throws its shot in a direction oblique to the line of troops or to the face of a work, against which it may be firing, is called AN OBLIQUE BATTERY.

A battery, which takes a line of troops or the face of a work

exactly in flank, throwing its shot from one extremity of the line towards the other, is called A RAKING OR ENFILADING BATTERY.

A battery, which takes a line of troops or the face of a work in rear, or in reverse, is called A REVERSE BATTERY.

Consequently, according to the direction in which they are fired upon, a line of troops or the face of a work may be said to be exposed to A DIRECT FIRE, AN OBLIQUE FIRE, AN ENFILADING FIRE, OF A REVERSE FIRE.

In a fire of cannon and musquetry, the balls are impelled in a right line nearly;* from the muzzle of the piece towards the object fired at.

In a fire of mortars, on the contrary, the bomb or shell describes a considerable curve in its flight. It is first thrown upwards at an oblique angle, usually of 45°, and falls down upon the object at the end of its course.

From the difference just mentioned, a fire of mortars is sometimes styled A VERTICAL FIRE; whilst the fire of cannon or musquetry is styled A HORIZONTAL FIRE.

It will be observed, that these terms are not strictly accurate, for a shell does not fall vertically in any part of its flight, and balls are seldom fired in a direction exactly horizontal. They serve however, in a general view, to mark the distinction between the two modes of firing.

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* The term "nearly" is used, because, strictly speaking, the balls describe a curve in their flight; but these curves are very inconsiderable, except at long ranges, when the fire becomes uncertain.

CHAP. X.

CONSTRUCTION OF THE SECTIONS AND PLAN OF A FIELD BATTERY.

*The three sections and the plan of a battery, which are now about to be explained, are contained in the third and fourth plates of this volume, but as usual, on rather a smaller scale, than is laid down in the text. It was judged proper to divide them, in order to suit the size of the book; but the same necessity does not apply to the Learners, who may conveniently comprise the whole of these figures upon a common-sized sheet of drawing paper. It will be observed that the following directions are calculated for that purpose, and when the learners shall have finished their drawings accordingly, the various figures, illustrated in this chapter, will be arranged within the limits of the same margin, in the following manner.**

Section 1.	Section 2.	Section 3.
	PLAN OF THE BATTERY.	

This being explained, we shall proceed with our constructions.

* Before they do their finished drawings, the learners ought previously to draw the sections separately on a larger scale, for a reason stated at the end of the construction of Fig. 3. See page 170.

1. Draw a rectangle for your margin, about seventeen and a half regular inches by twenty-five.

2. Make a scale of ten feet to an inch. It is constructed as follows.

Draw a right line seven inches long: divide it into seven equal parts: subdivide the first division of it into ten equal parts: and make the middle subdivision more conspicuous than the other.

Under the left extremity of your scale write the number 10; and from thence write successively under each division the figure 0, and the numbers 10, 20, 30, 40, 50, and 60.

3. About two regular inches and three quarters below the top of your margin, draw a line parallel to it, for the ground line of the sections which are about to be drawn.

FIGURE I.

SECTION OF AN ELEVATED MORTAR BATTERY.

4. At any convenient distance, for instance, at about two and a quarter regular inches from the left side of your margin, mark a point on your ground line, for the bottom of the interior slope of the parapet of your battery.

5. Set off 1 foot, 10½ inches, for the base of the interior slope of the parapet: raise a perpendicular of 7 feet 6 inches, for the height of the parapet; and draw the interior slope, which will be in the proportion of one fourth of the height.

6. From the crest of the parapet draw a horizontal line, outwards, 18 feet long, for the thickness of the parapet at top.

From the extremity of this horizontal line, drop a perpendicular to the ground line, upon which perpendicular, set off 1 foot 6 inches, from the top downwards, to represent the dip of the parapet, which will be in the proportion of one twelfth.

7. Draw the superior slope of the parapet.

The lower part of the last drawn perpendicular will represent the exterior height of the parapet, or in other words the height of the exterior slope.

8. The base of the exterior slope must be equal to its height, which is 6 feet. You will therefore set off this distance upon the ground line, and draw the exterior slope accordingly.

9. Make the berm 3 feet wide, measuring from the foot of the exterior slope of the parapet outwards.

10. From the extremity of the berm, measure 6 feet further upon the ground line, which will be equal to the base of the reverse slope of the ditch.

From thence drop a perpendicular of 6 feet for the depth of the ditch; and join the outside of the berm and the foot of this perpendicular by an oblique line, in order to represent the reverse slope of the ditch, the proportion of which is as 1 to 1.

11. Draw a horizontal line 14 feet 6 inches long, to show the width of the ditch at bottom; from the extremity of which raise a perpendicular meeting the ground line.

12. In front of this perpendicular, set off 4 feet upon the ground line; which will be equal to the base of the front slope of the ditch.

Join the point, thus marked, and the foot of the last drawn perpendicular by an oblique line, in order to represent the front slope of the ditch, which is in the proportion of two thirds.

13. At the distance of 7 feet in rear of the interior slope of your parapet, mark a point upon the ground line for the front of your mortar platform.

Let your platform be 8 feet long; and mark a second point upon your ground line, at the above distance in rear of the former, to show the tail of it.

That part of the ground line, which is comprehended between

these two points, will represent the top of your platform, which is supposed to agree with the natural level of the ground.

14. Draw a line parallel to the top of your platform at the distance of 4 inches below it. The space comprehended between the two will show the thickness of the planking.

15. Draw a second line parallel to the top of your platform, at the distance of 8 inches below the last drawn line, in order to represent the bottom of a sleeper.

16. Draw perpendiculars 12 inches long in front and rear of your platform, to show the extremities of your planking and sleeper.

It next remains to represent the individual planks of the platform. These may of course be of various breadths; but in the present instance, we shall suppose them to be each 1 foot broad, in which case eight planks will be sufficient for the whole platform.

17. You will therefore divide the length of your platform into eight equal parts, and at all the points of division, thus found, draw small perpendiculars across the planking to show each plank.

Your platform is now complete, it not being usual to represent the spikes or screws, in a section done on so small a scale.

The interior slope of the parapet of a field battery is usually reveted with sand bags or fascines,* either of which materials will stand very well at a slope of one fourth, such as we have given to our present figure.

Let us suppose that our mortar battery is to be reveted with fascines. Before we proceed to represent this kind of revetment, as it appears in a section, some explanation of the nature of it will be proper.

* In a mortar battery, it is not always essentially necessary to revet any part of the parapet, although it is usually done. In a gun battery, revetments may be considered indispensable.

A FASCINE is a faggot composed of brushwood, strongly pressed and bound together in a cylindrical form. Fascines are usually made of about 9 inches in diameter, and may be of various lengths, but are seldom used less than six feet long.

In building with fascines, they are laid in courses one above the other, so as to cover the whole slope or surface, that is to be reveted; and the work is secured by driving pickets or stakes, several feet long, through each fascine, into the body of the parapet or other mass of earth, which a revetment of this kind is intended to retain.

These particulars being explained, we shall continue our section.

18. The first or lowest course of a fascine revetment is usually sunk a few inches in the ground. You will therefore produce the interior slope of your parapet about 4 inches below the ground line, to show the depth at which the first course of fascines is proposed to be laid.

19. Mark also a point upon the interior slope, at the same distance below the crest of the parapet.

20. Divide the distance between the two points, thus marked, into ten equal parts, in order to show the height of the several courses of fascines, each of which is supposed to be about nine inches in diameter.

21. Ten small circles of that diameter, must next be drawn to agree with the above spaces, and in such a manner, that the back of each circle shall touch the interior slope of the parapet.

If your instruments are not fine enough to describe such very small circles in the usual manner, the most convenient method of drawing them will be as follows.

First draw a line parallel to the interior slope of the parapet, at the distance of 9 inches in front of it; and afterwards draw small perpendiculars to this line, from the various points which were

marked on the interior slope, in order to show the height of the several courses of fascines.

By this means, you will form ten small squares, one above another, equal to each other and touching the interior slope of the parapet.

Then by rounding off the angles of all these squares, you will convert them into ten small circles of about 9 inches diameter, as above required, in order to show the several courses of fascines, used in your revetment.

The FASCINE PICKETS ought next to be represented, but as there are pickets supposed to be driven through every course from the bottom upwards, as was before observed; the whole of them would not be introduced in a figure done on so small a scale, without creating confusion. We shall therefore only draw those pickets, which will be sufficient to explain the method used in driving them; namely, one picket through the fourth, a second through the seventh, and a third through the tenth or uppermost course of fascines.

22. At the distance of 3 feet 6 inches, in front of the interior slope of your parapet, mark a point upon the ground line, in order to show the position of the sharp end of a picket, supposed to be driven through the middle of the fourth course of fascines.

A picket usually tapers, being smaller towards the point than at the head. On so small a scale it is not worth while to notice this difference. The sides of the picket may therefore be represented by lines nearly parallel, so that the section of it will exactly resemble that of a palisade.

Draw the section of your picket accordingly, making it about 1½ inch thick. Let it pass through the center of that circle which represents the fourth course of fascines; and let the sharp end of it terminate upon that point on the ground line, which was marked for the purpose of determining the position of the said picket.

23. Through the middle of the seventh and tenth courses of

fascines of your revetment, draw two new pickets, in a direction parallel to that of the former picket, and equal to it in length and thickness.

24. A small portion of the original interior slope of the parapet remains above the uppermost fascine. Alter this part of your parapet a little, by drawing a new line with rather a greater slope: the above small portion of the interior slope being supposed to remain unreveted.

The section of your mortar battery is now complete.

FIGURE II.

SECTION OF AN ELEVATED GUN BATTERY.

25. At any convenient distance, not likely to interfere with your former figure, for instance, at about twelve and a quarter regular inches from the left side of your margin, mark a point, upon the same ground line, to represent the bottom of the interior slope of the parapet of your proposed gun battery.

26. Make the base of the interior slope of your parapet 1 foot 10½ inches. Let your parapet be 7 feet 6 inches high; and draw the interior slope, which will be in the proportion of one fourth of the height.

27. Make your parapet 18 feet thick at top: give it a dip of 1 foot 6 inches, which is in the proportion of one twelfth; and draw the superior slope.

Draw also the exterior slope of your parapet, making the base of it equal to its height, which is 6 feet.

28. Make the perpendicular height of the sill of your embrasure 2 feet 9 inches above the ground line, by marking a point at that height upon the interior slope of the parapet.

29. From the above point draw a horizontal line, outwards, 12 feet in length, from the extremity of which drop a perpendicular of 6 inches.

Join the sill of the embrasure and the foot of this perpendicular by an oblique line, which you will produce until it meets the exterior slope of the parapet.

This oblique line will represent the sole of the embrasure, which has a small dip or slope downwards. The above horizontal line and perpendicular are imaginary lines, and were drawn merely for the purpose of determining the said dip, which is in the proportion of one twenty-fourth.

30. In rear of the parapet, set off 15 feet upon the ground line, for the length of the platform; and raise a perpendicular of 10 inches to show its rise.

31. Join the top of this perpendicular and the bottom of the interior slope of the parapet by an oblique line, which will represent the top of the platform.

32. Parallel to the top of your platform, at the distance of 2½ inches below it, draw a line to show the bottom of the planking: and at the distance of 6 inches below the planking, draw a second parallel line, for the bottom of a sleeper.

33. Upon the front of your sleeper, and touching the parapet, describe a figure resembling a small square, having its sides each 8 inches, in order to represent the hurter.

34. Divide the remainder of your platform, in rear of the hurter, into 15 equal parts, and at each point of division, draw small perpendiculars across your planking to represent individual planks.

Draw also two small perpendiculars for the ends of the sleeper.

The section of your platform is now complete; and it only remains to represent the form of the ground behind it, a part of which is supposed to be raised as high as the rear of the platform, in order to give it proper solidity.

35. For this purpose, from the highest point of the tail of your platform, draw a horizontal line backwards, 2 feet long, to represent a portion of the ground immediately behind it, which may be made level. We shall suppose the remainder of the raised ground to be formed with a slope.

36. From the extremity of your horizontal line, drop a perpendicular to the ground line, to show the height of the said slope, in rear of which set off 2 feet 6 inches upon the ground line, for the base of it, and draw the slope.*

37. Make the berm of your battery 3 feet wide.

38. Set off 6 feet for the base of the reverse slope of your ditch; and draw the said slope, making the ditch 6 feet deep.

39. Make your ditch 11 feet wide at bottom: and draw the front slope of the ditch, giving it a base of 4 feet.

The ditch of your gun battery, which is now finished, is made smaller than that of the mortar battery, which you before drew, although the parapets in both sections have the same general dimensions. The reason of this difference may easily be understood. The parapet of the gun battery has embrasures or large openings left in it at certain intervals; whereas that of the mortar battery is solid throughout. Consequently the former requires less earth than the latter; and may be supplied from a smaller ditch or excavation.

In a gun battery, not only the interior slope of the parapet, but also the cheeks of the embrasures are reveted. The former

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* In the rough section of a gun battery, contained in the preceding chapter, the slope is represented close to the tail of the platform, without any level space between. That method would be too weak in practice, as may appear evident on inspecting the figure alluded to, which was drawn merely for the sake of explanation (*See page* 152).

should have a slope of at least one fourth, as represented in our figure; but in the revetment of the checks, the slope is usually diminished to one sixth of the height.

The section of your gun battery is now complete; with the exception of the revetments, which we shall not introduce in our present figure, as they might make it appear confused.

FIGURE III.

SECTION OF THE EPAULMENT OF AN ELEVATED BATTERY.

40. At any convenient distance, not likely to interfere with your last figure, for instance at about four regular inches and three quarters from the right side of your margin, mark a point upon the same ground line for the bottom of the interior slope of the epaulment.

41. Make the base of this slope 1 foot 10½ inches: let the height of the epaulment be 7 feet 6 inches; and draw the interior slope of your epaulment accordingly.

42. Make your epaulment 12 feet thick at top, which is two thirds of the usual thickness of the parapet of a battery. Give it a dip of 1 foot 6 inches; and draw the exterior slope of your epaulment, making the base of it equal to its height, which is 6 feet.

43. Make the berm 3 feet wide.

44. Make the reverse slope of the ditch of your epaulment 6 feet: let the ditch be 6 feet deep, and 6 feet 6 inches wide at bottom; and give it a front slope of 4 feet.

Our section is now complete, with the exception of the revetment, which we shall next proceed to draw.

Let us suppose that the battery, of which our present figure represents the epaulment, is reveted with sandbags.

SANDBAGS are strong bags of an oblong form, which when required for use are filled with earth and tied up. They are then built in courses, in proportion as the work is raised of which they are to form the revetment, and are laid exactly like bricks or stones in the front of a wall, being disposed alternately as headers and stretchers.* Consequently, when viewed from a certain distance, a sandbag revetment has very much the appearance of a stone wall.

We shall suppose the average length of each of the full sandbags composing the revetment of our battery to be 2 feet, their average width to be 1 foot, and their average depth 6 inches.†

It is usual in practice to level the ground for the first course of sandbags, sometimes sinking a few inches below the surface, in order to give it a proper bed or foundation; but it is not worth while to notice the groove, which may thus be formed, on so small a scale as that of our present section.

45. You will therefore divide the interior slope of your battery into 15 equal parts, and mark points accordingly, to represent the height of the several courses of sandbags, each of which, as before mentioned, is supposed to be 6 inches high.

From the various points, thus marked, draw short lines, outwards, parallel to the ground line, in order to represent the top and bottom of the several courses of sandbags.

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* In building, a stone or brick is called a header, when one end of it agrees with the face or surface of a wall; but if laid in such a manner that one of its sides agrees with the face of the wall, it is termed a stretcher.

† The actual dimensions of the sandbags used in the British service are a little less than the above, which have been chosen in preference, being whole numbers.

46. In front of the bottom of the interior slope of your epaulment, mark a point upon the groundline, at the distance of 2 feet; and from this point, draw a line parallel to the interior slope, meeting the first or nearest of the last drawn parallel lines.

This will form a small parallelogram resting on the groundline, the base of it being 2 feet, and its height 6 inches, which is intended to represent a sandbag of the first or lowest course of the revetment, supposed to be laid as a header.

Every alternate course of sandbags is supposed also to be laid as a header; and the top and bottom of every course is already drawn: it therefore only remains to draw the back of each.

47. Parallel to the interior slope of the epaulment, and at the distance of 2 feet measured horizontally, you will therefore draw lines to represent the back of each of the remaining odd courses of your revetment, commencing with the 3d, 5th, 7th, &c. and continuing in the same manner, in regular order, until the whole are finished. This being done, all the odd courses in your sandbag revetment will be represented by small parallelograms equal to each other. The even courses must next be drawn; which is done according to the same method nearly.

48. Upon that line, which represents the top of the first or the bottom of the second course of sandbags, mark a point at the distance of 1 foot, measured horizontally from the interior slope of the epaulment; and from this point draw a line parallel to the said slope and meeting the bottom of the third course of your revetment.

By this means you will have formed a new parallelogram, smaller than those which you before drew, but of the same height. This is intended to represent a sandbag of the second course of the revetment, supposed to be laid as a stretcher, and which consequently occupying less depth in the section of a work, than another sandbag of equal size laid as a header would do.

49. Represent, in the same manner, the back of all the remain-

ing even courses of your revetment, that is to say of the 4th, 6th, 8th, 10th, &c. &c., by lines drawn for that purpose, parallel to the interior slope, at the distance of 1 foot set off horizontally.

This being done, the whole of the courses of your sandbag revetment will be represented in your section by small parallelograms of two different sizes, the longest of them representing the HEADERS, and the others the STRETCHERS. These small figures must next be altered a little, in order to give them a more exact resemblance of sandbags.

50. Round off in a small degree all the angles of your parallelograms, but particularly of those ends of them, which are supposed to be sunk or buried in the body of the parapet; besides which, you will further alter your headers, by making to the buried end of each a small addition, in order to represent the form of the neck of the sandbag, which is supposed to be tied up, as was before observed.

The revetment being now correctly represented, your section is complete.

51. Pen your three sections, leaving breaks in the groundline between them, to show that they are distinct figures; and dot the imaginary lines, excepting that perpendicular in your first figure, which represents the interior height of the parapet, as also the corresponding perpendicular in your third figure; neither of which could well be introduced, without making the revetments appear confused.

52. Over your first figure, write, in a conspicuous manner, *Section of an elevated Fascine Mortar Battery.*

53. Over your second figure, write, in a conspicuous manner, *Section of an elevated Gun Battery.*

54. And over your third figure, write, in a conspicuous manner, *Section of the Epaulment of an elevated sandbag Battery.*

Before the Learners draw their sections on a scale of ten feet to an inch as above directed, in order to form part of a complete drawing, including also the plan within the same margin, it will be best for them to draw the sections separately on a much larger scale, such as five feet to an inch, because the former scale will scarcely be large enough to give a just notion of the smaller parts of a battery, as represented in a section, unless the drawing is executed with very great neatness and accuracy.*

PLAN OF AN ELEVATED BATTERY FOR THREE GUNS AND FOUR MORTARS.

1. At any convenient distance, for instance at about nine regular inches and a quarter, below the ground line of your sections, and parallel to it, draw a right line across your paper to represent the bottom of the interior slope of the parapet of your proposed battery.

The length of the battery, which must be set off upon the above line, will be as follows. The three guns, at 18 feet each, which is the usual interval allowed per gun, will take up a space of 54 feet: the four mortars, at 15 feet per mortar, will require a space of 60 feet; and we shall allow 12 feet for the breadth of the base of a traverse, supposed to be placed between the guns and mortars. This gives a total of 126 feet for the length of the battery, exclusive of the epaulments.

* In making a scale of 4 or 5 feet to an inch, the line drawn for that purpose should not be divided into parts of 10 feet, but into divisions of 1 foot each, and the left division of the scale should be subdivided into parts of 2 or 3 inches each.

2. Bisect the line which you have just drawn, and from the middle of it set off 63 feet each way. The two new points, thus found, will of course be 126 feet distant from each other; and the space comprehended between them will therefore represent the total length of the battery, the center of which will, by this arrangement, agree with the middle of your paper. We shall suppose the guns to be placed at the right, the mortars at the left of the battery.

3. From that point, upon the above line, which represents the left extremity of your battery, you will therefore set off 60 feet for the extent of your mortar battery; to the right of which set off 12 feet for the traverse. The remaining 54 feet will show the extent of the gun battery.

4. From those two points, which mark the width of your traverse, drop perpendiculars, each 18 feet long, to show the length of it.

Join the extremities of these two perpendiculars by a right line, and the form of the base of your traverse will be complete.

The epaulments of your battery must next be marked out, which is generally done by giving them a certain splay outwards, so that each of them shall form a moderately obtuse angle with the face or front of the battery. Let us suppose that 1 foot in 4 is considered a good proportion for the above splay. The epaulments will then be drawn as follows.

5. From the extremities of your battery drop perpendiculars 12 feet long, and from the ends of these perpendiculars draw lines, outwards, parallel to the face of the battery and 3 feet long.

6. From each extremity of your battery, draw an oblique line through the end of the nearest of the two last drawn lines; and make these oblique lines each 26 feet long.

The two oblique lines, thus drawn, will represent the bottom of the interior slope of your epaulments.

The base of the parapet of your battery is supposed to be 25

feet 10½ inches wide, as may be observed by referring to your first and second sections; but the base of the epaulments of your battery is supposed to be only 19 feet 10½ inches wide, as may be observed by referring to your third section.

7. In front of that line, which represents the bottom of the interior slope of the parapet of your battery, you will therefore draw a line parallel to it at the distance of 25 feet 10½ inches, in order to represent the foot of the exterior slope of the parapet.

8. And in front of those two lines, which represent the bottom of the interior slope of the epaulments of your battery, draw lines parallel to them, at the distance of 19 feet 10½ inches, to represent the foot of the exterior slope of the said epaulments.

9. You before set off 26 feet for the length of each of your epaulments. From the points thus marked draw perpendiculars outwards, as far as the exterior slope, to show the extremities of them.

10. The base of the interior slope of the parapet, as also of the epaulments, and of the traverse of your battery, being every where equal to 1 foot 10½ inches; you will draw lines outwards, at the above distance, parallel to those lines which represent the bottom of the various interior slopes.

The last drawn parallels will represent the interior crest of the parapet of the battery, as also the interior crest of each epaulment, and the crests of the traverse.

11. In rear of those lines, which represent the foot of the exterior slope of the parapet and of the epaulments of your battery, draw lines parallel to them, at the distance of 6 feet, which is the space allowed for the base of the exterior slope of each.

The last drawn lines will represent the exterior crest of the parapet, and of the two epaulments, of your battery.

We shall suppose that the extremities of the epaulments of our battery are unreveted, and that they are formed with a slope whose base is equal to its height.

12. From the extremities of your two epaulments, upon those lines, which represent the interior crest of each, you will therefore set off 7 feet 6 inches, which is equal to the interior height of the epaulment.

And upon those lines, which represent the exterior crest of each epaulment, you will, in like manner, set off 6 feet, which is equal to the exterior height of the epaulment.

The above distances are intended to determine the base of the slope of the extremity of each epaulment.

13. Connect the adjoining points, thus marked, near the extremity of each epaulment, by right lines; and from the ends of these right lines, draw oblique lines to the nearest angles of the extremities of your two epaulments.

This being done, you will have a correct representation of the extremities of each of your epaulments, as they ought to be laid down in the plan of a battery, under the supposition that they have the above-mentioned slope of 1 to 1.

It was before stated, that the meeting of two oblique planes will, in all cases, necessarily form either a ridge or a furrow, as may be observed in the roofs of houses: and the same thing of course holds good in works of fortification, where by reason of the various slopes commonly used, many oblique planes are constantly combined together.

The ridges and furrows, thus formed, like those of the glacis and ramps, which you have already drawn, are always represented in a plan by right lines.

14. Join all the opposite angles of the crest and base of your traverse by right lines, for the above reason.

At the front of your traverse, where it is connected with the parapet of the battery, these lines will represent furrows: at the rear of your traverse they will represent ridges.

15. Join also the opposite angles of the shoulder of your bat-

tery by right lines, which will show the furrows, formed by the meeting of the interior slopes of the parapet and epaulments; as also the ridges, formed by the meeting of their superior and exterior slopes.

16. In the space of 54 feet, which was originally marked for the extent of your gun battery, set off 9 feet from the two extremities inwards.

17. Bisect the distance between the two points thus found, which will give you a third point.

The above three points, which are exactly 18 feet apart, will show the center of each embrasure.

18. Through these points draw perpendiculars intersecting the parapet, which you will also produce to some distance in rear of

nt the lines of fire of your three guns.

section of your gun battery you will find that the height of the sill of your embrasure is 2 feet 9 inches.

19. From the points above marked, you will therefore set off 8¼ inches, outwards, upon every line of fire, to represent the base of the slope of the sill of each embrasure, which is supposed to be equal to one fourth of its height.

20. Through the new points, thus found, draw lines parallel to the face of the battery, and 2 feet 2 inches long, one half of which length must be set off to the right, the other half to the left, of each line of fire.

The last drawn lines will represent the length of the sill of the embrasure, or in other words the width of the neck of the embrasure at bottom.

21. In front of the sill of every embrasure, measure 18 feet upon the line of fire, on each side of which point, set off 4 feet 6 inches, upon a line drawn parallel to the face of the battery.

The lines, thus drawn, which are 9 feet in length, show the width of the embrasures towards the front, at the distance of 18 feet from the sill.

22. From the right and left extremities of the sill of every embrasure, you will therefore draw oblique lines through the corresponding extremities of the last drawn lines.

These oblique lines correspond with the bottom of the cheeks of the embrasures, and at the same time show their splay.

In the section of an elevated gun battery, which you before drew, if you drop a perpendicular from the mouth of the embrasure to the ground line, and measure the distance between the bottom of this perpendicular and the foot of the exterior slope of the parapet, you will find it to be 1 foot 9¼ inches.

23. The above distance represents the base of the exterior slope of the embrasure: you will therefore, upon each line of fire, in your plan, set off 1 foot 9¼ inches in rear of the foot of the exterior slope of the parapet, and through the points thus found, draw right lines parallel to the face of your battery. These lines will represent the mouths of your embrasures.

24. Produce the bottom of the cheeks of your embrasures, outwards, until they meet the last drawn lines; and the form of the soles of your embrasures will be complete.

The slope of the cheeks of your embrasures must next be represented, which we shall suppose to be in the proportion of one sixth of their height.

In order to do this properly, you must refer to the section of your elevated gun battery; and measure the interior height, as also the exterior height of the merlon, taken vertically, above the sole of the embrasure.

The interior height of the merlon, measured vertically, as above directed, will be found to be 4 feet 9½ inches nearly.

25. You will therefore take 9½ inches, which is one sixth of the above height nearly, and set it off, in your plan, from the cheeks of all your embrasures, outwards, in a perpendicular direction, so as to cut the interior crest of the parapet.

In like manner the exterior height of the merlon, measured verti-

cally, by referring to your section, as above directed, will be found to be 4 feet 0½ inches nearly.

26. You will therefore take 8 inches, which is one sixth of the above height nearly, and set it off, in your plan, from the cheeks of all your embrasures, outwards, in a perpendicular direction, so as to cut the exterior crest of the parapet.

27. Join the corresponding points, thus marked, near the cheeks of each embrasure, by drawing right lines between the interior and the exterior crests of the parapet.

The last drawn lines will show the top of the cheeks of all the embrasures.

28. Connect the extremities of the above lines, and the adjoining angles of the sole of each of your embrasures.

This being done, the embrasures and merlons of your gun battery will be complete.

29. Draw lines parallel to the foot of the exterior slopes of your battery all round, at the distance of 3 feet in front of them, in order to show the breadth of the berm.

30. Draw a second set of parallels in front of the berm, at the distance of 6 feet, in order to represent the extent of the base of the reverse slope of the ditches of your battery.

As the ditches of the gun and mortar batteries are supposed to be of unequal widths, you will draw a perpendicular from the foot of the reverse slope of your battery outwards, in the direction of the right side of the base of your traverse produced. This line is to mark the division between the broad and the narrow parts of the ditch.

31. Make the ditch of your mortar battery 14 feet 6 inches wide at bottom, drawing a parallel at the above distance, to represent the outside of the bottom of it.

32. Make the ditch of your gun battery 11 feet wide at bottom, drawing a parallel at the above distance to represent the outside of the bottom of it.

The broad part of the ditch is continued, not only in front of the parapet of the mortar battery, but also before the traverse, in the manner now represented in our figures, because traverses likewise require a considerable additional quantity of earth; so much so that, in making them, it is generally found necessary to procure materials from the rear of the battery.

33. Make the ditches of your epaulments 6 feet 6 inches wide at bottom, drawing parrallels at the above distance to represent the outside of the bottom of each.

34. Set off 4 feet, all round, for the base of the front slope of the ditches of your battery; and draw parallels, at the above distance, to mark the extent of it.

35. Produce outwards, beyond the berm, those two perpendiculars, which were first drawn, in representing the extremities of the epaulments of your battery; and let these produced lines mark the extremities of the ditches of the said epaulments.

36. The extremities of the ditches of your epaulments may be formed with a slope. Parallel to the last drawn lines, at the distance of 4 feet, you will therefore draw lines across the bottom of the ditches of your epaulments, in order to show the extent of the base of the said slope.

The broad and narrow parts of the ditch of the front of your battery may also be formed so as to meet each other with a slope.

37. To the right of that perpendicular which marks the division between the broad and narrow parts of your ditch, and parallel to it, at the distance of 4 feet, you will therefore draw a right line to show the extent of the base of the said slope; and produce the top of the front slope of your mortar battery, until it meets the last drawn line.

38. Draw lines connecting the corresponding points of the top and bottom of the ditches of your battery, at every angle, in order to represent the ridges and furrows formed by the meeting of the various slopes.

The whole of the ditches of your battery are now complete: and it only remains to draw the platforms.

39. Upon each line of fire of your gun battery, set off 15 feet, from the bottom of the interior slope of the parapet, backwards, in order to show the length of the platforms; and through the new points, thus marked, draw lines parallel to the face of the battery, to represent the position of the tail of each platform.

We shall leave that platform which is to the right of our gun battery, unfinished for the present, so that you will apply the following directions to the construction of the two other platforms only.

40. To the right and left of the line of fire of each of the two left guns of your battery, set off 4 feet 6 inches upon the bottom of the interior slope of the parapet.

And to the right and left of each of the same lines, set off 7 feet upon those lines, which were before drawn, in order to represent the position of the tails of your platforms.

The points, thus found, will determine the width of your platforms, which is supposed to be 9 feet in front and 14 feet in rear

41. Draw the sides of your platforms.

42. Draw a line parallel to the front of each platform, at the distance of 8 inches in rear of it, in order to represent the back of the hurter.

43. Divide the remainder of the length of each platform into 15 equal parts, marking points for that purpose upon the line of fire; through which points you will draw right lines parallel to the front of the platform, in order to represent the joints of the planks.

In the right platform of our gun battery which remains to be drawn, we shall suppose that the sleepers only are laid. The manner of drawing a platform in this imperfect state is as follows.

44. Instead of 4 feet 6 inches take only 4 feet, and instead of 7 feet take only 6 feet, and mark points accordingly, at the above distances, to the right and left of the line of fire of your unfinished platform, in front and in rear of it; in the same manner that you set off the width of your former platforms.

45. Draw right lines connecting the corresponding points thus marked, in order to show the exterior sides of the right and left sleeper of your platform.

46. Make the above sleepers 6 inches wide.

47. Exactly half way between these, draw the center sleeper of your platform, making it also 6 inches wide, the middle of which will of course exactly agree with the line of fire.

48. Bisect the distance between the center sleeper and each of the others, both in front and in rear of your platform.

The points thus found will give you the position of the middle of the second and fourth sleepers, which you will draw accordingly, making them 6 inches wide like the others.

49. Draw two small circles of about three inches diameter, near the front and rear of each sleeper, and touching the sides of it, in order to represent the heads of pickets, which are sometimes driven into the ground, for the purpose of steadying the sleepers.

50. Upon your two former platforms draw lines to show the position of the center of each sleeper.

Upon or near the above lines mark five points on every plank, to represent the heads of spikes, supposed to be driven through it into the sleepers, for the purpose of confining it in its proper place.*

These points may be marked, not exactly in the middle of each plank, but alternately towards the front and rear of it, as the latter is usually considered the strongest method of spiking down planks.

In drawing the plan of a battery on a very large scale, such as 4 or 5 feet to an inch, the back and front of each hurter would require to be altered from their present form, in the manner

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* In drawing platforms, or other woodwork, on a much larger scale, the heads of spikes might of course require to be represented by small circles, instead of points.

directed in Nos. 51 and 52: but on so small a scale as 10 feet to an inch, it is not worth while to make the alteration alluded to. The Learner may therefore, in constructing his battery, proceed to No. 53 at once, without noticing the intervening paragraphs, which are introduced merely for the sake of rendering the directions complete, so as to apply to any other larger scale, that might be used.

It is to be observed that the hurter rises nearly 6 inches above the bottom of the interior slope of the parapet; as also above the adjoining part of the platform: and the back of it is laid parallel to the interior slope, which is in the proportion of one fourth of its height.

Consequently the back of the hurter must also have a similar slope.

51. In front of that line, which represents the back of each hurter, you will therefore draw a second line parallel to it, at the distance of about 1¼ inch, in order to represent the base of the above slope.

For the same reason the front of the hurter ought not exactly to agree with the bottom of the interior slope of the parapet, as at present represented in our figure, but with a part of the slope, about 6 inches higher.

52. In front of the bottom of the interior slope of the parapet, and parallel to it, you will therefore draw lines at the distance of 1½ inch, in order to represent the proper position of the front of each hurter: and produce the sides of every platform until they meet the said lines.

53. Near each end of every hurter represent a spike, placing the said spikes over the middle of the outside sleepers.

Your gun platforms are now complete, as far as is intended, two of them being represented in a finished state.

54. In the space of 60 feet, which was originally marked for

the extent of your mortar battery, set off 7½ feet from the two extremities inwards; and divide the intermediate space into three equal parts.

55. From the various points, thus marked, which will be exactly 15 feet apart, draw perpendiculars, backwards, to represent the line of fire of your four mortars.

And upon these perpendiculars, at the distance of 7 feet in rear of the bottom of the interior slope of the parapet, set off 8 feet for the length of each platform.

56. Make your mortar platforms 8 feet wide, and draw the three left platforms of your battery accordingly, in the form of regular squares, setting off one half of the above width to the right, the other half of it to the left of each line of fire.

57. Divide the length of each of the above three platforms, into eight equal parts, and through the points of division thus found, draw lines parallel to the front of your platforms, to represent the joints of the planks.

In our remaining platform, which is not yet drawn, we shall suppose the sleepers to be laid only.

58. Through those two points, which were previously marked to show the length of the above platform, draw lines parallel to the bottom of the interior slope of the parapet, to show the position of the ends of the sleepers.

59. At the distance of 3 feet 6 inches to the right and left of the line of fire of your unfinished platform, draw lines parallel to it, to show the exterior sides of the right and left sleepers; and draw the said sleepers, making them 8 inches wide.

60. Draw two new sleepers between the former, parallel to them and equal to them in length and width; taking care to divide the distance in such a manner, that all the intervals between your four sleepers shall be equal to each other.

61. Near the front and rear of each sleeper, on both sides of it and touching it, draw small circles of about 3 inches diameter, to

represent the heads of pickets, which are sometimes driven into the ground, for the purpose of steadying the sleepers.

62. On your three former platforms, draw lines in order to show the position of the center of each sleeper.

63. Upon or near the above lines, mark four points on every plank to represent the heads of spikes, in the same manner that you before represented the spikes of your gun platforms.

This being done, the plan of your gun and mortar battery will be complete.

64. Pen your plan, representing the interior crest of the parapet and epaulments, as also the crests of the traverse, and the back of each hurter, by thick lines.

65. Dot the line of fire of your right gun, and of your right mortar. Dot also those imaginary lines which were drawn for the purpose of determining the splay of the embrasure of your right gun, and that of the right epaulment of your battery.

66. In any convenient place, near the bottom of your drawing, insert a finished scale; and pen it.

67. Over your plan write, in large letters, PLAN OF AN ELEVATED BATTERY FOR THREE GUNS AND FOUR MORTARS.

68. Over your scale, write the words, *Scale of* 10 *feet to an inch.*

69. And finish your margin in the usual manner.

REMARKS.

The field battery, which you have now drawn, is supposed to be an offensive battery, such as might be used in a siege.

The ditches in your figure are drawn of a more regular form, than would be necessary in actually constructing a battery of this description. The only thing essential in practice, as far as regards the ditch, is to give the reverse slope of it, a sufficient base to

prevent it from falling. If this is done, and a berm of two or three feet left, the stability of the parapet will be provided for. Independent of its contributing to the above object, the berm is also useful during the construction of a field battery, and therefore should not be omitted. These points being attended to, any irregularities in the form of the outline of the ditch, or in the depth or width of it, are not of importance, nor is the front slope of it of the least consequence; because the security of the parapet does not in any degree depend upon it, so that it matters not whether that side of the ditch stands or falls. This remark applies to offensive batteries only, in which the principal or sole use of the ditch is to supply materials. In defensive field works, on the contrary, no less attention must be paid to the form and preservation of the ditches than of the parapets.

Experience has proved that in military works, one cubic yard of excavation from a ditch or trench, will furnish as nearly as possible the exact quantity of materials required for completing one cubic yard of rampart or parapet; provided that the soil excavated is in its natural state, not previously loosened by artificial means, and that, in forming the work, the proper precaution of ramming or otherwise pressing it into a compact mass has been taken. These suppositions generally hold good in works of fortification, and may therefore be assumed as just grounds for calculation; but if such were not the case, as for instance, in works executed in a loose slovenly manner, the proportion between any excavation and the elevation of earth formed from it, might vary considerably from the above ratio.

But, although in conformity with the rule, which has just been stated, I have supposed the total quantity of earth, excavated from the ditches of our battery, to be nearly equal in measurement to the quantity contained in the parapets and epaulments; you will find, on examining any of the sections, that the area of the excava-

tion, there represented, is much less than that of the corresponding elevation. The reason of this difference is, that, on account of the angular form of the extremities of the battery, the mean length of the ditch is much greater than that of the parapets and epaulments added together. Consequently, as the former has more length, it could not possibly be equal to the latter in cubic measurement, according to our supposition, unless its other dimensions were smaller in proportion.

The same remark holds good in all other works having salient angles. In any small inclosed field work for instance, the mean length of the ditch must necessarily be much greater, than that of the work itself which it surrounds. Consequently in a section taken through any part of the work, the area of the excavation will necessarily be much less than the area of the corresponding elevation.*

CHAP. XI.

SUPPLEMENTARY REMARKS ON PLAN DRAWING, AS APPLIED TO THE PLANS OF MILITARY WORKS.

If you examine attentively the plan of the battery, which you have just drawn, you will perceive, that that part of your figure, which represents the sloping extremity of the epaulment of your battery, forms an exact section of the epaulment itself.

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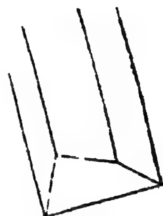
* In speaking of the actual construction of works, and particularly when used in opposition to an excavation, the term "elevation" implies the whole of the elevated parts, that is to say all those parts, which in the section of a work would appear above the ground line. But in speaking of the delineation or representation of works, &c. it always implies a kind of geometrical drawing, the nature of which has been fully explained in Vol. I.

In all cases, it is to be remarked, that whenever the extremity of any work has a slope, the plan of it will, in some measure, resemble the section of the same work; but it will not always be a regular or correct section of it.

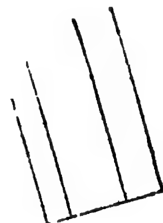
It becomes a regular section, in your present figure, partly because the slope is equal to the height, and partly because the extremity of the epaulment is perpendicular to the general line of that work.

Draw another plan of the epaulment only of your battery, on a separate piece of paper, but on the same scale.

Here follows a sketch of the epaulment of a battery, on a much smaller scale, but sufficiently clear to explain the remarks which are about to be made.

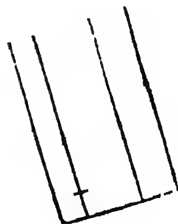


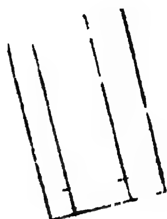
Rub out the slope represented in the plan, and restore the figure to its original state, as it stood before the slope was drawn.



Now let us suppose, that instead of a slope equal to the height, the extremity of the epaulment of the battery had a slope equal to half the height only.

From the extremity of the epaulment, upon that line which represents the interior crest of it, mark a distance equal to half the interior height of the epaulment.





From the extremity of the epaulment, upon that line which represents the exterior crest of it, mark a distance equal to half the exterior height of the epaulment.



Connect the points thus marked; and the adjoining angles of the work by oblique lines, and the plan of the extremity of an epaulment, having a slope of one half its height only, will be complete.

Rub out superfluous lines; and you will perceive, that there still remains a figure resembling a section of the epaulment, but it is no longer an exact section.



Rub out your figure, and by the same rule, draw the plan of the extremity of an epaulment having a slope of double its height.

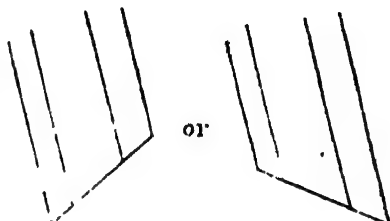
The same remark will apply here as in the last case; the form of a section still remains, but not a regular one.

Rub out your figure.

I shall now proceed to show the effect produced in the appear-

ance of the sloping extremity of any work, as represented in a plan, when it is not laid out at right angles.

Draw the various lines of an epaulment, as before, but instead of a perpendicular, draw an oblique line to show the extremity of it.



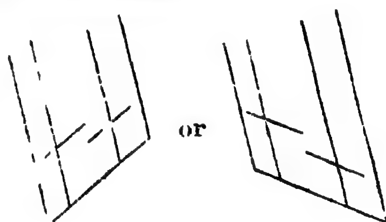
This being done, let us suppose, first, that the extremity of the epaulment is to have a slope equal to its height.

Draw a line parallel to the extremity of the epaulment, at a distance equal to the interior height of that work, and let this line intersect the interior crest of the epaulment.

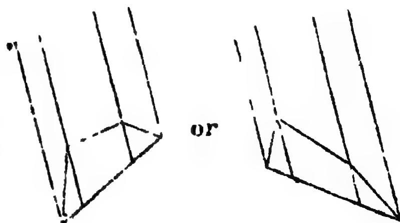
After finding the above intersection, rub out the remaining parts of the said line.

Draw a second line parallel to the extremity of the epaulment, at a distance equal to the exterior height of that work; and let this line intersect the exterior crest of the epaulment.

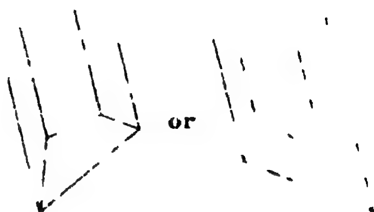
After finding this intersection, rub out the remaining parts of the last drawn line.



Connect the above points of intersection and the extremities of your oblique line, by right lines.



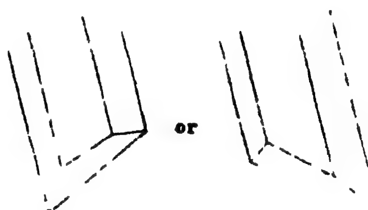
Rub out those parts of your original figure, which will now become superfluous; and the form of an epaulment having an oblique extremity is complete, in the manner in which it ought to be represented in a plan.



You may now observe, that the plan of the sloping extremity of an oblique epaulment still retains some resemblance of a section of that work, but it is no longer an exact section, although the slope is equal to the height.

If instead of having a slope equal to its height, the extremity of an oblique epaulment had a smaller or greater slope, the figure of it would of course become still more distorted, if compared with the proper section.

Draw the plan of an oblique epaulment, according to the same rule as the last, but giving it a slope of only one half of its height. The figure of it will then be as follows.



Some resemblance of a section can still be traced, as you may perceive, but it is a very distorted one.

In finished plans of Fortification, or of works containing a great number of slopes, a learner is apt to be puzzled, unless he understands the nature of the various lines; and the small disproportioned or distorted sections, which always appear in the plan, are particularly apt to perplex him; so that often the most simple works may appear complicated in a plan, for this reason.



For instance, nothing is a simpler thing than one of the traverses of the covered way, the section of which consists of a small parapet with a banquette in rear of it. The plan of it in outline is also exceedingly simple, it being merely a rectangle.

But in the finished plan, in which the slopes are expressed, in addition to the lines of the parapet and banquette, there appears a small distorted section at each extremity of the traverse, on account of the slopes of the said extremities, which are almost always reveted. Owing to these additions, the traverse, which is the simplest of all parts of a fortress, becomes in the finished plan, to all appearance, one of the most complicated.

These details, which are seldom or never explained, in the common modes of teaching Fortification, generally prevent the learner from acquiring any just notion of the works represented, even although he may have drawn a great number of plans.

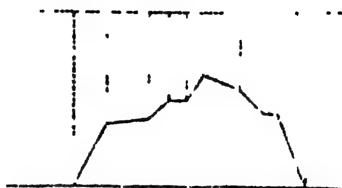
The same remarks, which have just been made respecting the plan of the epaulment of a battery, apply, in like manner, to all other works which terminate abruptly at one extremity; such as for instance the faces of a ravelin, or those of a tenail.

In order to explain this observation, I shall take for my example a simple tenail.

We will first draw a regular section of that work, but on a smaller scale, omitting the thickness of the revetments, as also the cordon and coping; but showing all the necessary slopes.



Draw a dotted horizontal line over the section of the tenail, and from every point in the section raise dotted perpendiculars, meeting the said horizontal line.



Mark the dotted horizontal line by the letters a b, and mark the various spaces comprehended between the dotted perpendiculars, in regular order, by the numbers 1, 2, 3, 4, 5, 6, 7, 8, and 9.

Then the dotted horizontal line a b will represent a plane of projection, the use of which was explained in the Principles of Plan Drawing.

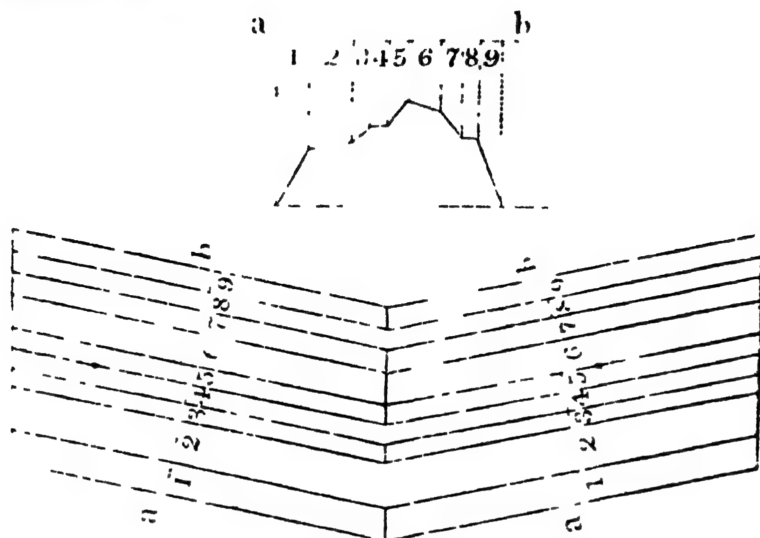
Draw two lines of any convenient length forming an obtuse angle to represent the front of the simple tenail, of which you have already drawn the section.

In order to complete the plan of your simple tenail, you will next draw lines parallel to the front of it; making the distances between these parallel lines, in the plan, correspond exactly with the distances between the various dotted perpendiculars, in the section.

Draw also two right lines to represent the extremities of your tenail.

Draw lines to represent the ridges and furrows formed at the meeting of the various slopes near the reentering angle; and let these lines extend across the whole of the tenail, excepting the berm, banquette, and terreplein. There no ridges or furrows must be represented, because these parts of the work are horizontal, or nearly so.

Mark the spaces between the various parallel lines, in the plan, with the numbers 1, 2, 3, 4, 5, 6, 7, 8, and 9, so as to agree with the corresponding spaces, in the section, to which they are respectively equal.



The space 1, in the plan, corresponding with the space also marked 1, in the section, represents the interior slope of the rampart of the tenail, that is to say, if this work is not reveted in rear. But if the tenail were supposed to be reveted in rear, then the space 1 in the plan would represent the slope of the gorge revetment.

The space 2 is the terreplein.

3 The slope of the banquette.

4 The banquette.

5 The interior slope of the parapet.

6 The superior slope of the parapet.

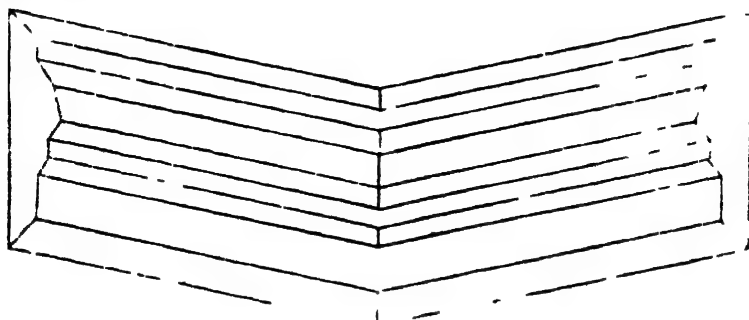
7 The exterior slope of the parapet.

8 The berm.

9 The slope of the scarp revetment of the tenail.

Now if the extremities of your tenail are supposed to have a slope of one half their height, then the same rule will apply in completing the plan of them, which you before followed, in drawing the plan of the oblique extremity of an epaulment having that slope.

Draw the two extremities of your tenail accordingly, giving each of them a slope of half its height, and rub out superfluous lines and marks.



The plan of a finished tenail is now complete, on examining which you will find, that, in conformity with the above general rule, the extremities of it do, each of them, resemble a distorted section of the work.

The extremities of tenails, ravelins, and other permanent works of fortification, are almost always reveted, and scarcely ever have a slope of more than one sixth of their height. In the above example we have chosen a much greater slope, merely for the sake of rendering the figure more clear.

But the extremities of a work, although constructed with a slope, may not always be laid out in one continued right line, which has hitherto been supposed to be the case. Sometimes one or both of the angles may be rounded off. This is usually done at that extremity of a traverse, which faces towards the glacis.

When the sloping extremity of a work is partly rectilinear and partly curved, those parts of it, which are laid out in a right line, will still retain, in a plan, some resemblance of a section of the work; but these sections, on account of the circular parts, will be imperfect at the angles; for as circular slopes do not meet abruptly in any points, no ridges are formed by them; and consequently no lines are drawn across them, in representing them in a plan. Where these lines are wanting, there the resemblance of the section of the work will be incomplete.

We shall first illustrate this remark, by means of two very simple solid bodies, the pyramid and cone.

Draw the plan of a square pyramid of any convenient size. Draw also the plan of a cone.



The sides of the pyramid slope regularly every way from the base to the vertex. The cone also has a regular slope, in like manner, from every part of the base towards the vertex.

But by reason of the circular form of the base of the cone, all the slopes of its surface blend gradually into each other without forming angles or ridges any where; and consequently the circle which you have drawn to represent the base of your cone, with the point which marks its vertex, will form a complete plan of that body; no additional lines to represent ridges being necessary. In the pyramid, on the contrary, the meeting of the various sloping sides forms ridges, which are represented, in the plan, by right lines drawn from the vertex to the angles of the base.

The square pyramid therefore is a body with four sloping sides or extremities, laid out in right lines, each of which sloping extremities, as you may observe, is represented in the plan by a triangle,

that is to say, by a figure resembling a section of the pyramid itself, taken through the vertex.

The section of a cone, taken under the same supposition, that is to say through the vertex, is also a triangle like that of the pyramid; but when you examine the plan of the cone, no appearance whatever of a section of it can be traced This is owing to the circular form of the base, from whence the slopes take their rise

As the pyramid resembles the cone in so many circumstances, and might in fact be converted into one by merely rounding off its angles; you may easily conceive, that the same difference, which is observable in the plan of these two solids, would be produced in the sloping extremity of a military work, by rounding off one of its angles.

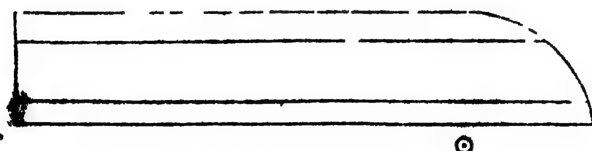
In order to explain this more fully, draw four lines parallel to each other, to represent the plan of the parapet of a battery

Draw a right line perpendicular to the above, to represent the left extremity of your battery.

Let us suppose, that the right extremity of the battery is to be rounded off or curved at one angle, and that the curve is to be an arc of a circle touching the exterior side of the work.

Complete your figure accordingly, and mark the center of your arc by a point.

The Learners are recommended to draw their figures on a much larger scale than the following.



Let us now suppose that each extremity of the work is to have a slope equal to its height.

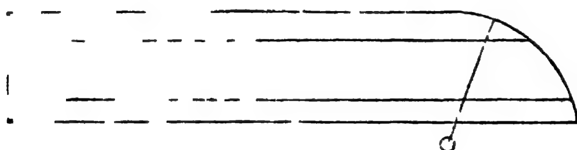
In that case, the plan of the left or right-lined extremity of the battery, will, of course, when finished, represent an exact section of the work.

Draw the said section accordingly.

This being done, mark a point upon the curved part at the right extremity of your figure, and from thence draw a line inwards, perpendicular to the curve.

The curve, in our present figure, is supposed to be an arc of a circle, but any line perpendicular to an arc, will, if produced far enough, pass through the center of it.

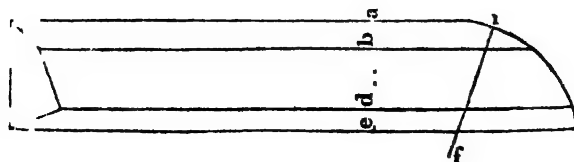
You will therefore produce your perpendicular, until it meets the center from whence the curve was described, when it will, of course, become a radius.



Mark the point on the curve, from whence your produced perpendicular or radius was drawn, by the figure 1.

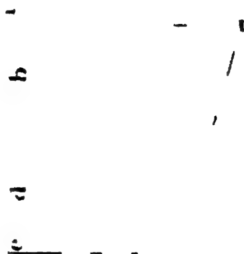
Mark the center of your arc by the letter f.

And mark the original lines of your parapet by the letters a b d e, according to a dotted line drawn perpendicularly across it, in any convenient place.



In order to explain the remaining operations more clearly, a part of the following figures are drawn on a larger scale. In these, the left extremity of the battery is omitted, because the directions, now about to be given, relate only to the right extremity of that work, the slope of which remains to be drawn.

The enlarged figure of the right extremity of the battery will be as follows.





The Learners will of course go on with their original figures, without any alteration, they being supposed to be drawn, from the first, on a scale sufficiently large.

Near the plan of your battery, draw a section of it, on the same scale.

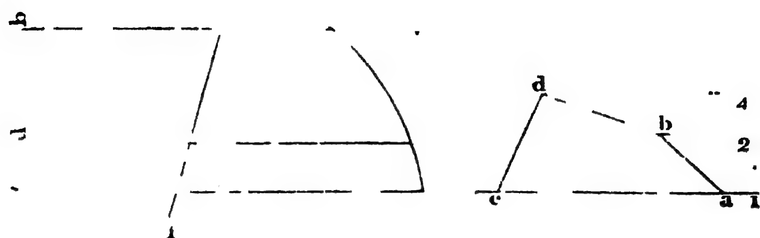
Mark the various points of your section, so as to correspond with the letters a, b, d, and e, in the plan.

Near your section, raise a dotted perpendicular from the ground line of it, to represent a scale of heights: and draw dotted horizontal lines, from the interior and exterior crests of the parapet, to meet the said scale of heights.

From the interior and exterior crests of your parapet, as represented in the section, drop dotted perpendiculars to the ground line.

Mark the bottom of the scale of heights by the figure 1. Mark e point, where it is intersected by the lower horizontal line, by

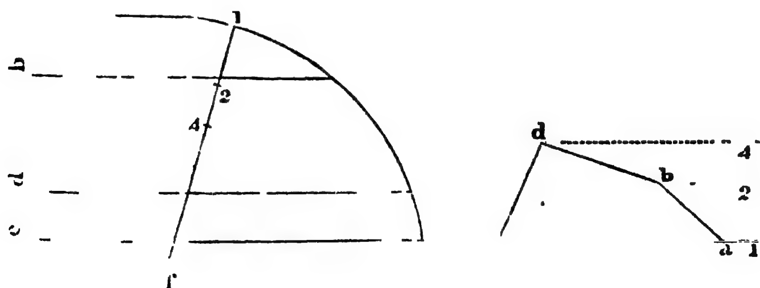
the figure 2, and mark that point, where it is intersected by the upper horizontal line, by the figure 4.



It will be evident, that the distance, between the points 1 and 2 on the scale, will be equal to the exterior height of the parapet; and that the distance, between the points 1 and 4 on the scale, will be equal to the interior height of the parapet.

From the point 1 in your plan, set off, upon the line 1 f, a distance equal to the exterior height of the parapet, and mark it by a point, opposite to which write the figure 2.

From the same point, set off, in like manner, upon the same line, a distance equal to the interior height of your parapet; mark this new point by the figure 1.



The space 1 2, in the plan, is equal to the space 1 2 in the section; and the space 1 4, in the plan, is equal to the space 1 4, in the section. And, in like manner, all other parts of the plan and section, which are marked alike, correspond with each other.

The next thing required is to draw a line parallel to the curve, through the point marked 2 in the plan, and this parallel must be produced, until it meets or cuts that line, which represents the exterior crest of the parapet.

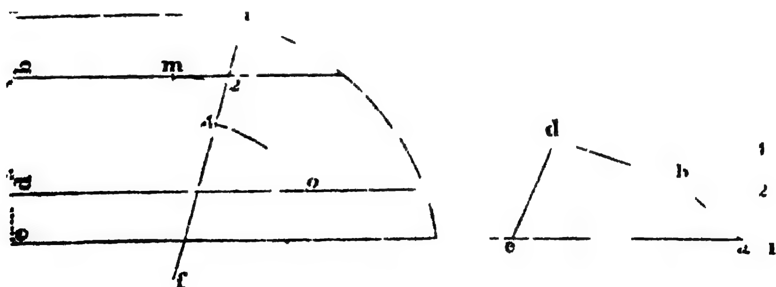
The curve in our present figure being a regular arc of a circle, the method of drawing another curved line, parallel to it, is of course to describe a second arc from the same center

From the center f, with the radius f 2, you will therefore describe an arc, and produce it until it meets or cuts the exterior crest of the parapet. Mark the point where they meet, by the letter m.

The point, thus found, will be a true point, in a new curve, which must afterwards be drawn, in order to show the form of the top of the slope of the curved extremity of your work

Through the point 4, in your plan, you will, in like manner, draw a curve parallel to your original curve, and produce it, until it meets or cuts the interior crest of the parapet Mark the intersection by the letter o

The point o will also be a true point in the above-mentioned curve, which remains to be drawn, and the points m and o will be the extremities of this proposed curve.



Having thus found the extremities of your proposed curve, it remains to find some true central or intermediate points in it, which be done as follows.

Draw a dotted parallel line, in your plan, half way between the interior and exterior crests of your parapet; and mark the point, through which it passes, by the letter c.

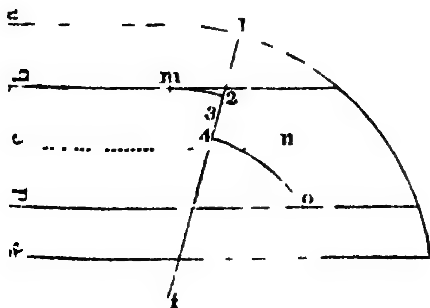
Take a corresponding point, in your section, half way between the interior and exterior crests of your parapet, marking it, in like manner, by the letter c.

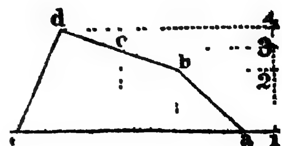
From the point c, in your section, drop a dotted perpendicular to the ground line draw also a dotted horizontal line, from the same point, meeting the scale of heights, and mark the point where they meet by the figure 3.

Then the distance 1 3, on your scale, will represent the exact height of the parapet, at any point half way between the interior and exterior crests of it.

Take the above distance 1 3 in your compasses, and from the point 1, in your plan, set off an equal distance upon the line 1 f; and write the figure 3 at the extremity of it.

Through the point 3, in your plan, in the manner before described, draw a dotted curved line parallel to your original curve; and produce this new curve, until it cuts the dotted parallel line, which is drawn through the point c. Mark their common intersection by the letter n.





The point n, thus found, will be a true intermediate point in the proposed curve.

By the same method, you may easily find any greater number of true intermediate points for your curve.

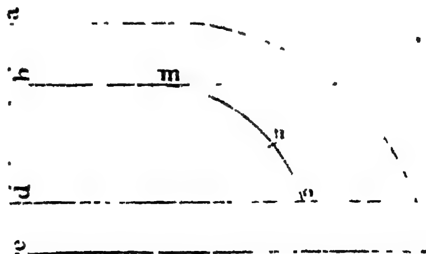
For instance, instead of dividing the superior slope of your parapet into two equal parts only, by the dotted parallel line e, in the plan, and by the corresponding point e, in the section; you might have divided it into four equal parts in both.

Then instead of gaining only one point 3 in your scale of heights and plan, you would have gained three points; by means of which, instead of finding only one true point n between the extremities of your proposed curve, you would have found three true points.

In like manner, any other greater number of true intermediate points might be found, if more than three were judged necessary.

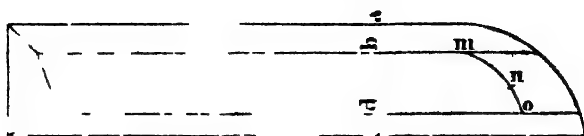
The points, which we have gained in our present figure, are quite sufficient for explaining the principle of the operation which is to be performed. You will therefore rub out all the superfluous lines and arcs in your plan, leaving only the true points m, n, and o.

Through these points draw a curve.

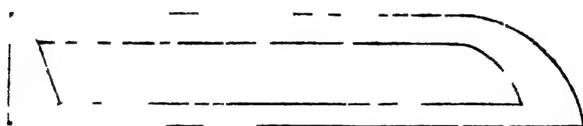


The former smaller figure, given in the book, will now serve for the purpose of explaining the remaining operations. The

state of it, after the curved line m n o *is supposed to be drawn, according to the process above described, will be as follows.*



b out the superfluous lines and letters in your figure.

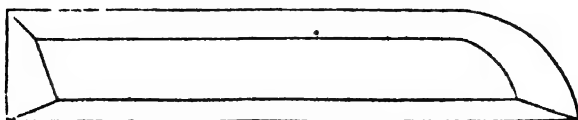


The curve which you drew last, through the points that were marked m n o, represents the top of the slope of the curved extremity of your parapet.

This slope and the exterior slope of the parapet gradually meet each other, and blend into one continued curved superficies, so that no ridge is formed there, and consequently no line must be drawn across the part where these two slopes unite.

But the slope of the extremity of the parapet and the interior slope of it meet each other abruptly in an angle. They will therefore form a ridge.

Draw a right line to represent the said ridge, and your figure will be complete.



You have now drawn the plan of the parapet of a battery, with

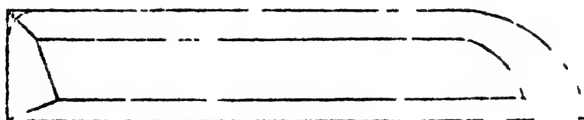
sloping extremities, the one laid out according to a right line, the other curved.

At the right-lined extremity of the battery there appears a representation of a section of the work; but at the other extremity, by reason of the curve, there is not the least resemblance of a section.

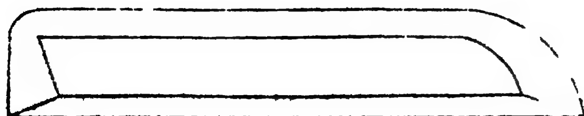
You may now easily conceive, that if the sloping extremity of a battery or other work, were partly right-lined, and partly curved; the right-lined part of it, when laid down in a plan, would have some resemblance of a section of the work, whilst the rest of it would not.

For instance, at the right-lined extremity of your present figure, from that point, as a center, which represents the left extremity of the exterior crest of the parapet, describe an arc outwards, with a radius equal to the exterior height, or in other words to the base of the exterior slope of the parapet.

The arc, thus drawn, will touch the foot of the exterior slope of the parapet, and also the bottom of the slope of the extremity of the battery. Let it be produced no further after it meets these lines.



Rub out those parts of your figure, which pass without the arc: rub out also the original ridge near the arc.



The figure, in its present state, represents the left extremity of your battery, partly laid out in a right line, but with the remaining part of it, near the exterior angle, rounded off. And if you examine it with attention, you will see that the plan of the said sloping extremity forms very nearly an exact section of the work, every part of it being complete, excepting the exterior slope of the parapet only. There the section is imperfect, owing to the alteration in the form of the work, occasioned by the curve.

Plans of buildings, or other civil works, in which few slopes occur, do not afford any scope for exemplifying the remarks contained in this chapter; therefore, although they are, properly speaking, an illustration of the principles of plan drawing, it was judged most suitable to introduce them here, after treating of works of fortification, to which they more particularly, or rather exclusively, apply. To officers or others employed either in constructing or in taking plans of military works, these remarks will be useful; for in works of this description, so great a multiplicity of slopes are constantly used, that it must be of advantage to understand the properties of sloping bodies, and the various forms produced by the meeting of them under given circumstances.

There is another peculiarity to be remarked in the plan of sloping works. When the face of a slope is cut by any object, strongly marked upon it, such as the entrance of a plain gateway,* or sallyport, the figure of the said object, as it ought to be represented, in the plan of the sloping part of the work, will in all cases resemble a geometrical elevation of the object itself; in some

* By a plain gateway, I mean one of a simple form, not ornamented with columns, mouldings, or other architectural ornaments, projecting beyond the face of the work, in which it is supposed to be placed. It will easily be understood, on perusing the following observations, that they cannot apply to gateways of the last-mentioned description.

cases, it may even form an exact elevation of it. And it is further to be observed, that the same circumstances have an effect upon these elevations, that were pointed out as affecting the former figures, before* explained, resembling sections, which so often appear in the plan of works.

For example, if the base of the slope of any side of a work is equal to its height, then in a plan of the work, the outline of any gateway, &c. marked upon the slope, will be an exact elevation of the gateway itself: but if the slope is less or greater than the above proportion, or in other words, if the base and height of it are unequal, then the form of the gateway, as marked upon the slope, will, in a plan of the work, still bear some resemblance to the elevation of the gateway, but it will be a disproportioned not a correct elevation of it.

To explain this remark take any convenient scale, such as 10 feet to an inch, and draw the section of a simple work, sloping in front and rear, but horizontal at top.

For instance, draw a right line for the ground line of your section, upon which mark a point (a) for the bottom of the interior slope of the work, and draw the said interior slope, making the base and height of it each 24 feet.

Mark the top of the interior slope by the letter b from thence draw a horizontal line, b c, 15 feet long, to represent the terre-plein or horizontal part of the work, in front of which, draw the exterior slope c d, making the base of it 12 feet.

This being done, your section a b c d will be complete. We shall next draw a figure to represent the plan of the same work.

Draw a right line of any convenient length, for the bottom of the exterior slope of the work, in rear of which, set off successively and perpendicularly;

First, 12 feet for the exterior slope of the work, the base of which is equal to half the height,

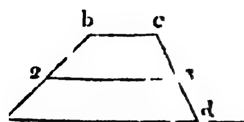
Secondly, 15 feet for the terreplein or thickness at top;

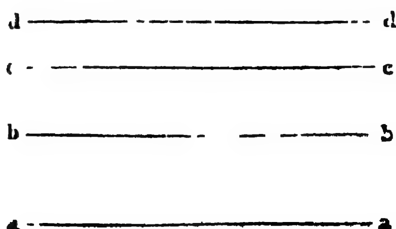
Thirdly, 24 feet for the interior slope of the work, the base of which is equal to the height And through the points, thus marked, draw lines, parallel to the former, in order to complete your plan, which being done, you will mark the various lines in your plan by the letters a a, b b, c c, and d d, in order to show that they agree with the corresponding points, marked by the same letters in your section.

We shall next suppose, that a gateway 6 feet wide and 12 feet high is cut through the work, which we have just drawn; and in order to render our succeeding operations more clear, we shall further suppose, that the said gateway is of the simplest possible form that could be adopted, being constructed with a flat arch like the door of a common dwelling house; in which case its geometrical elevation will of course be a rectangle whose sides are of the above stated dimensions, namely 6 feet by 12.

This being premised, we shall proceed to represent our supposed gateway in both of our figures, and first in the section.

At the distance of 12 feet, above the ground line a d of your section, draw a line parallel to it, to represent the top of the arch of the gateway, which will of course, from this construction, be exactly one half of the total height of the work; and mark the line, thus drawn, by the numeral figures 2 and 3.

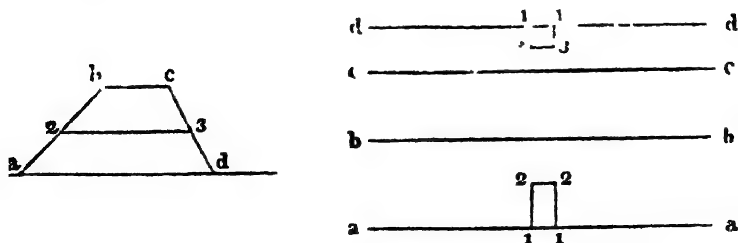




Upon the line a a, in your plan, which represents the bottom of the interior slope of the work, mark points 1 1, at the distance of 6 feet apart, to represent the width of the gateway and the position of the bottom of it, opposite to which, on the line d d, which represents the bottom of the exterior slope of the work, mark two corresponding points 1 1, at the same distance apart, and for the same purpose.

It was before explained, that the height of the gateway is equal to one half of the total height of the work, through which it is supposed to be cut, and for this reason, it must be evident, that the points 2 and 3, in your section, where the top of the gateway meets the interior and exterior slopes, must be exactly half way up these slopes.

In order to find the position of the corresponding points in the plan, you will, therefore, from the points 1 1, on the line a a, draw perpendiculars 1 2, 1 2, half way across that space which represents the interior slope, and from the points 1 1, on the line d d, draw perpendiculars 1 3, 1 3, half way across the space which represents the exterior slope, which being done, draw right lines, connecting the points 2 2 and 3 3, in your plan.



The interior slope is 24 feet broad; consequently, the lines 1 2, 1 2, which extend half way across it, are 12 feet long; and therefore, the rectangular figure 1 2 2 1, which represents the manner, in which the entrance of the gateway ought to be laid down, in a

plan of the work, is exactly 12 feet by 6: that is to say, it forms a correct geometrical elevation of the gateway, the above being the exact height and width of it, as before stated. This coincidence arises from the nature of the interior slope, on account of the base of it being equal to its height.

In the exterior slope, on the contrary, the base and height are unequal, and the breadth of the slope, as represented in the plan, is only 12 feet; and therefore the lines 1 3, 1 3, which extend half way across the said slope, are 6 feet long. Consequently, the figure 1 3 3 1, which represents the form of the gateway, as appearing in the plan of the exterior slope, being reduced to one half of its proper height, although it still retains some resemblance of an elevation of the gateway, is no longer a correct but a disproportioned one.

The same effect will be produced, in all cases, whenever the base and height of the slope are unequal, that is to say, disproportioned not correct elevations of the gateway will be obtained, in a plan of the work; in which however, it is to be observed, that the width of the gateway will always remain correct, the height only varying from the real dimensions; and in proportion as the difference between the ratio of the base and height of the supposed slope increases, so much the more irregular will the disproportioned elevations, appearing in the plan, become.

For example, in our present figure, in which the base of the exterior slope is in the proportion of one half of its height, the height of the disproportioned elevation 1 3 is also reduced to one half of the actual height of the gateway.

But if the base of the above slope had been in the proportion of one third or one fourth of its height; then the height of the disproportioned elevation 1 3, would have been reduced, in the like

proportion, that is, to one third or one fourth of the actual heigl of the gateway.

For the same reason, if the base of the exterior slope had been not less, but greater than the height, as for instance two or thre times as great, then the height of the disproportioned elevation 1 3 would also have been increased, in the same proportion, that is to say, to two, or three times, the actual height of the gateway.

The above statements, in respect to the changes, which would be produced in these disproportioned elevations by any alteration in the slope, appear sufficiently clear, so that it has not been judged necessary to exemplify them by figures. The Learner may however easily convince himself of the accuracy of what has been asserted, if he will take the trouble to draw new sections and plans of the same simple kind of work, changing successively the base of the exterior slope, from one half to one third, or one fourth of the height, and afterwards to two or three times the height, but leaving all the other dimensions, both of the work and gateway, unaltered.

Gateways or sallyports with flat arches are not used in fortresses, that simple form having merely been above assumed for the sake of clearness. It will therefore be proper, before we proceed to a new part of our subject, to exemplify the manner, in which gateways of the common construction, that is to say, formed with arches curved at top, ought to be represented in plans of fortification.

For this purpose draw the plan of a work, resembling a ravelin in its outline, but of a more simple nature, in other respects; being supposed to be constructed with an interior slope, a terreplein, and an exterior slope only, so that the section of it shall exactly resemble that of our last figure.

Let the gorge and extremities be supposed to be reveted with a

slope; and represent them in the manner directed in a former part of this chapter, namely, the slope of the gorge revetment by parallel lines, and the extremities of the work by distorted sections.

Our work is now complete, with the exception of the proposed gateways, which we shall suppose to be formed with semicircular arches; but before we proceed to represent them in our plan, it is to be remarked, that the same rules, which we before applied to a gateway of the above more simple form, will also hold equally good in respect to a semicircular gateway, or to any other figure, even of the most complicated and intricate nature, which can be supposed to appear on the sloping side of any work.

The base of the interior slope of your work being equal to its height, you will therefore, in conformity with the rule just alluded to, draw an exact elevation of your semicircular gateway, on the left face of your work, upon that space which represents the interior slope of it.

The base of the exterior slope of your work being supposed to be only one half of the height, you will, in conformity with the same rule, draw a disproportioned elevation of your new gateway, also on the left face of your work, and exactly opposite to the former, upon that space, which represents the exterior slope: and in drawing this new elevation, let the breadth of it be every where precisely the same as before, but diminish the height of every part of it, to only one half of the height of the corresponding parts, as represented in your last drawn elevation.

In the left face of your work, the form of a semicircular gateway is now correctly represented, as it ought to appear in a plan of fortification, if the crown of the arch were continued as far as the slope on both sides. But it is proper to observe, that we have imagined this to be done, merely for the sake of more clearly illus-

trating the principle laid down. In real practice, arches are never continued, in the above manner, entirely across any slope, whose base is equal to its height or nearly so. Some part of an arch so constructed would necessarily be of a very weak inconvenient form, as may easily be conceived. It is therefore only in moderate slopes, such as those of revetments, that the arch is so continued. In earthen works, which must necessarily have a considerable slope, the arch, instead of being carried on through the whole of the profile as far as the slope, always terminates at the distance of some feet from it: and the remaining part of the earth, between the extremity of the arch and the surface of the slope, is cut away in such a manner as to form an open entrance to the gateway.

In order to explain these particulars, we shall next, on the right face of our work, draw another gateway, which we shall suppose to be also semicircular, and of the same dimensions as the former.

Let us likewise suppose, that the exterior slope of our work represents the slope of a scarp revetment; and therefore that the front of the new gateway may be continued as far as that slope, without inconvenience.

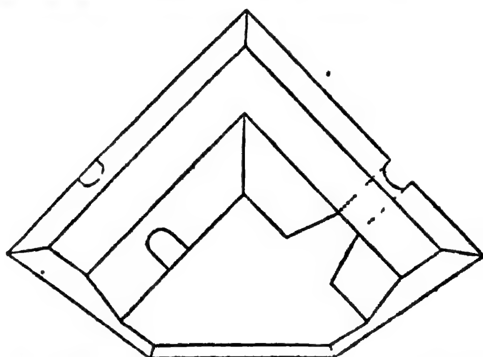
Upon that space, which represents the exterior slope of the right face of your work, you will draw a disproportioned elevation of your gateway accordingly; making this small figure equal and similar to that which you before drew, for the same purpose, on the exterior slope of the left face of your work. This being done, you will produce the parallel sides of the above small figure backwards, as far as the back of the terreplein.

The two lines, thus produced, will show the position of the covered part or arch of the gateway; for which reason they must be dotted, according to a rule before mentioned (*See page* 117), this

being the usual method of representing arches or other covered communications in a plan of fortification.

We shall further suppose, that the arch of our new gateway terminates perpendicularly, immediately under the back of the terreplein, without being continued under any part of the interior slope whatever.

From the extremities of the rear of your arch, that is to say from those two points on the back of the terreplein, where it is intersected by the last drawn lines, you will therefore draw right lines backwards, across the interior slope of the work, to represent the sides of the open entrance of the gateway; and in drawing these lines, you may give them a moderate splay outwards, so that the entrance shall be wider towards the rear than in front, this being the usual mode of construction followed.



Rub out that part of the bottom of the interior slope of your work, which interferes with the entrance of the gateway, that is to say, which lies between the extremities of your last drawn lines: and rub out also that part of the bottom of the exterior slope of the right face of your work, which forms the base of the distorted elevation of your gateway.

In the right face of your figure, you now have a correct representation of a gateway of the form, in which they are usually constructed in fortresses. Towards the rear, there is an open entrance cut through the interior slope of the rampart; the sides of which, being supposed to be reveted perpendicularly, are represented by right

lines. Then the arch of the gateway commences, and the back of it, being built not with a slope but perpendicularly, in the position before mentioned, is represented by a right line, which agrees with a part of the back of the terreplein. From thence it is continued in the direction, shown by the two dotted lines, until it terminates upon the scarp revetment, in the form of a disproportioned elevation, which is there produced by reason of the slope.

It is further to be remarked, that if a gateway has a descent, as is often the case, from the interior of a work, downwards, to the level of the ditch in front, according to a regular slope like that of a ramp, then the top and bottom of the descent should be marked by right lines, as is represented in the gateway of the left face of our present figure.* But if there is either no slope, of the nature above supposed; or if the said slope is concealed under the covered part of the gateway, which sometimes happens; then in penning the plan, no lines should be drawn across the entrances of the gateway, which should be left open both in front and rear, as is represented in that which appears on the right face of your present figure.

I shall conclude by remarking, that the figures resembling sections, before explained, are constantly introduced in finished plans of fortification, even when drawn upon a small scale. Those figures, on the contrary, which resemble disproportioned elevations of gateways or sallyports, as appearing on the slopes of revetments, are by no means common, but yet they are sometimes to be met with; and it has therefore been judged necessary to explain them:

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* It will be understood, that if the descent were formed by steps, not by a slope, it might, for the same reason, be proper to mark a part of the said steps, unless they were all concealed under the covered part of the gateway.

particularly as the strict rules of the art require, that they should always be represented, whenever the scale of the plan is large enough to admit of its being done without creating confusion. Besides which, an explanation of these last-mentioned details, although trifling in themselves, appeared essential to the complete illustration of that part of my subject, which treats of the principles of plan drawing.

CHAP. XII.

OF BARBETS.

It was before explained, that the guns of a fortress are placed upon the terreplein; and that they fire through openings, cut across the parapet, for that purpose, called embrasures.

Sometimes guns are placed in such a manner that they fire over the parapet, without the necessity of making any embrasures.

For this purpose a part of the terreplein is raised much higher than the rest of it, and forms a mound for the guns to stand upon.

These mounds are called BARBETS, and are usually formed at the salient angles of the bastions, or other works, in which they are used.

The general level of the terreplein is usually seven feet and a half lower than the crest of the parapet, whereas the barbet is only about three feet lower than the parapet; consequently the barbet may be considered as a kind of smaller terreplein, elevated above the great terreplein of the work, in which it is placed, to the height of about four feet and a half.

The advantage of barbet batteries is, that the guns can fire more freely in various directions, than is practicable through the common

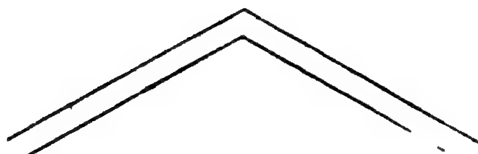
embrasures. Their principal disadvantage is, that neither the guns nor the gunners are sufficiently protected, on account of the lowness of the parapet of a barbet.

Consequently barbets are seldom used in a fortress, except at the commencement of a siege, before the enemy has established his first batteries against the place. After he has effected that object, the besiegers withdraw their guns from the barbet batteries, and place them behind embrasures.

The manner of drawing a barbet shall now be explained.

Draw two lines forming a salient angle, in order to represent the two faces of the bastion, or other work, where a barbet is proposed to be erected.

In rear of and parallel to them, draw two other lines, to represent the foot of the interior slope of the parapet.

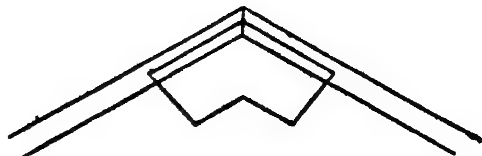


The space between these two sets of parallel lines will therefore, of course, represent the interior slope of the parapet.

About half way between these parallels, draw two new lines, also parallel to them, to represent the front of your proposed barbet.

At any convenient distance, draw lines parallel to the front of your barbet, in order to represent the reverse of it.

Draw the extremities of your barbet, making them perpendicular or nearly so, to the faces of your original work.



The four new lines, which you have now added to your figure, represent the form of the terreplein of the barbet.

The interior slope of the parapet of your original work, rises of course in a regular manner from the bottom towards the crest of it: and consequently, the barbet, as was before explained, being raised considerably higher than the bottom, but not quite so high as the crest of the parapet, will necessarily come part of the way up the slope.

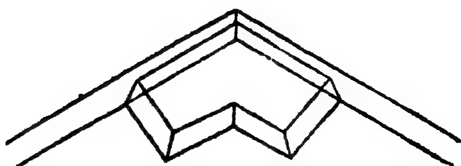
For this reason the front of the barbet is represented about half way up the interior slope: and those parts of the original bottom of the parapet, which intersect the barbet, will become imaginary lines.

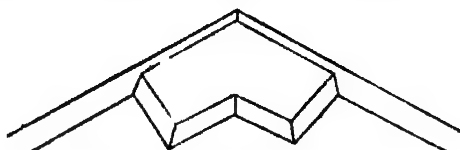
But if the barbet had been raised as high as the parapet itself, instead of being only about half that height, then it would have been on the same level with the crest of the parapet; and therefore, those lines which represent the crest of the parapet, would also have agreed with and served to represent the front of the barbet.

The barbet being raised some feet higher than the general level of the terreplein of the original work, must have a slope in rear, and at each extremity of it, at least equal to its height.

Draw parallels all round the barbet, except in front, in order to represent the above slope; and produce those at the extremities, until they meet the bottom of the interior slope of the parapet, but no further.

Then draw lines between the opposite angles, to represent ridges and furrows.





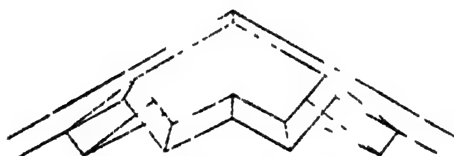
Rub out superfluous lines, and the plan of your barbet will be complete, excepting only the small ramps, which are necessary for ascending it.

These shall next be drawn.

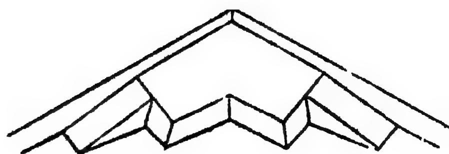


From the inward extremities of those two lines, which represent the front of your barbet, draw oblique lines backwards, to any convenient points at the bottom of the interior slope of the parapets of your original work.

These oblique lines will represent the exterior sides of each ramp.



Draw perpendiculars for the foot of each ramp: then draw the interior parallel to the exterior sides, producing them as far as the terreplein. Make the slope of each interior side of your ramps equal, at top, to that of the barbet: at bottom, let it fall away to nothing; and draw the whole of the lines necessary, in the manner before directed, in treating of ramps.



Rub out superfluous lines; draw the necessary diagonals across the new slopes, to represent furrows; and your figure will be complete.

Your figure, in its present state, represents a barbet constructed near the salient angle of a work, which is supposed to have no banquette.

If there had been a banquette, the ramps of your barbet should not have been placed close to the interior slope of the parapet, but at some distance from it, in order that they might not interfere with the banquette.

The method of drawing the ramps of a barbet battery, when there are banquettes on each side, shall now be explained.

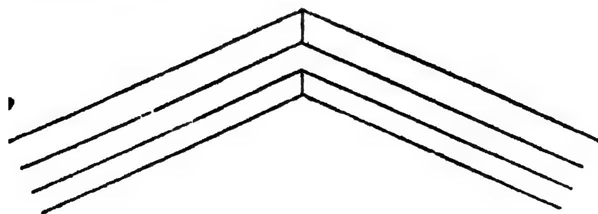
Draw two lines forming a salient angle as before, to represent the crest of the parapet of the work, in which the barbet is proposed to be constructed.

In rear of these and parallel to them, draw two other lines, to represent the bottom of the interior slope of the parapet, which agrees with the front of the banquette.

Draw a third set of parallels, also to the rear, to represent the back of the banquette.

Draw a fourth set of parallels, also to the rear, to represent the foot of the slope of the banquette.

Draw lines connecting the proper angular points, to represent the furrows formed in the interior slope of the parapet, and on the slope of the banquette.



This being done, the space, contained between the two outermost lines of your figure, will represent the interior slope of the parapet.

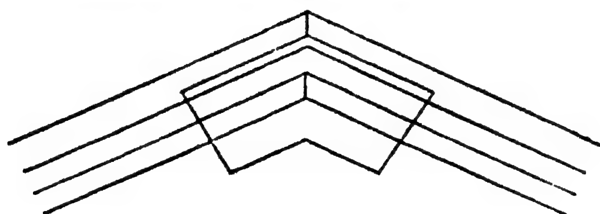
The center space will represent the banquette.

And the remaining space will represent the slope of the banquette.

Draw two lines on the interior slope of the parapet, parallel to the faces of the work, in order to represent the front of the barbet: and let these lines be nearer to the foot than to the crest of the interior slope; because a barbet is usually very little higher than the banquette.

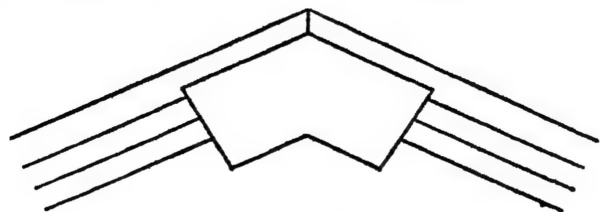
Draw the reverse of your barbet, parallel to the front of it, as before.

Draw also the extremities of your barbet, perpendicularly or nearly so, to the faces of your original work.



The four last drawn lines will represent the form of the terre-plein of your barbet.

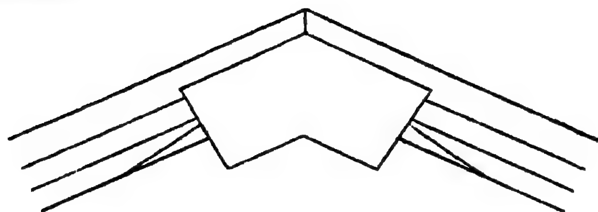
Rub out those parts of the interior slope of your parapet, and of your banquette, which now become superfluous.



Mark a point at any convenient distance upon the bottom of the slope of the banquette, in order to represent the foot of the exterior side of each ramp.

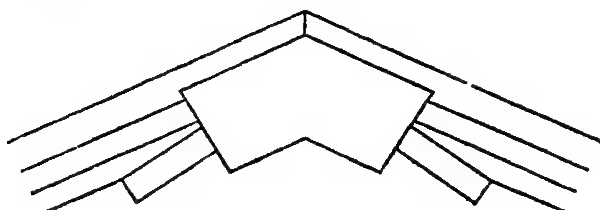
Mark also a point upon each extremity of your barbet, a little in rear of where it is intersected by the back of the banquette. These new points are to represent the top of the exterior side of each ramp.

Join these points by oblique lines, in order to represent the said exterior sides.

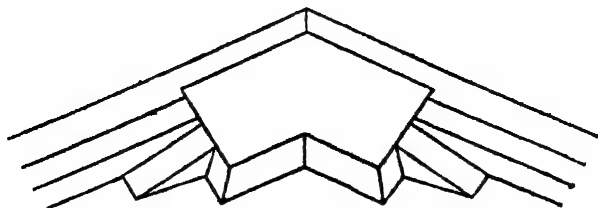


Rub out that part of the foot of the banquette on each side, which becomes superfluous, after the exterior sides of your ramps are drawn:

Then draw the bottom and the interior side of each ramp in the usual manner.



Draw the slope of the reverse of your barbet: draw also the slope of the interior side of each ramp in the usual manner; and complete the ridges and furrows formed by the meeting of these slopes.



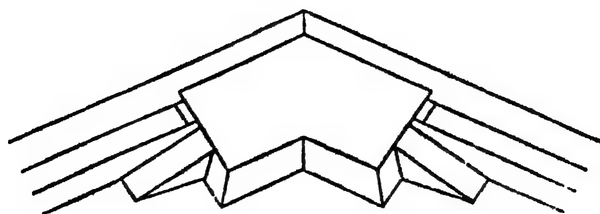
In the ramps which you before drew, the exterior side of each ramp rested upon the parapet, and the parapet being higher than the barbet, there could not of course be any slope downwards from the exterior side of your ramp towards the parapet. Consequently it was not necessary to draw any slope, on that side of the ramp.

But in your present figure, the exterior side of each of your ramps is placed near the banquette; and a barbet is always higher than a banquette; therefore both the exterior side of the ramp and that extremity of the ramp itself, which is near the banquette, must have a slope downwards, until they meet the level of the banquette.

The difference of level between the barbet, and the terreplein of any work in which it is constructed, is usually not less than four feet six inches, sometimes more: but the difference of level between the barbet and the banquette is seldom more than one foot six inches.

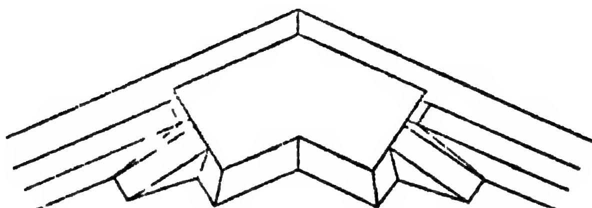
Consequently as all slopes are in proportion to their heights, the base of the slope of the reverse of the barbet, must be about three times as great as the base of the slope of that extremity of the barbet, which is near the banquette.

You will therefore draw lines across the tread of the banquette, parallel to the extremities of your barbet, at a distance equal to about one third of the breadth of the reverse slope of the barbet.



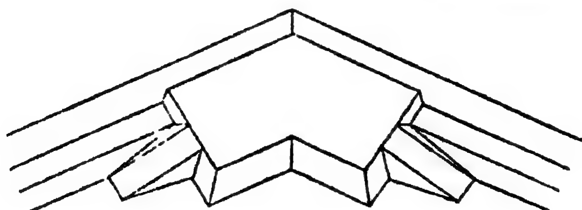
These lines will represent the foot of the slope of that part of the extremity of each barbet, which terminates upon the banquette. The slope of the exterior side of each ramp now remains to be drawn.

From the point, where the last drawn lines meet the back of the banquette, draw oblique lines to the bottom of each exterior side.



The whole of the slopes of your ramp are now complete, but a part of the furrows, which would be formed at the angles, remain to be drawn.

Rub out those parts of your banquette, which interfere with these slopes, and draw lines to represent the said furrows.



You have now finished the plan of a barbet, according to the mode, in which works of this description are usually constructed.

The guns, in a barbet battery, must be mounted upon platforms of the same strength and materials, as those before described.

It is to be observed, however, that instead of making a separate

platform for every individual gun, which is always done in batteries with embrasures; it is often usual, in barbet batteries, to construct large platforms, upon which two or more guns may be placed abreast of each other.

These LARGE BARBET PLATFORMS have the same depth from front to rear, and the same slope in that direction as a common platform. Their width, which is greater, will of course depend upon the number of guns proposed to be mounted upon them. If you allow a space of from twelve to fifteen feet per gun, in a barbet battery, it will be quite sufficient. A greater interval between the guns was allowed in our former battery, for a reason which has already been stated.

There is another method for enabling guns to fire over a parapet, without raising any interior mound or barbet for that purpose.

This is done by means of, what is called, A TRAVERSING PLATFORM.

The platform so called is a strong frame of timber, raised some feet higher than the ground; and capable of being traversed, that is to say, turned to the right or left, upon a fixed pivot, by means of trucks or small wheels which support it.

The gun, mounted on a common carriage, stands upon this frame, by which it is raised higher than the parapet; and by moving which, it is pointed to the right or left, as may be required. The breadth of the frame is just sufficient for receiving the gun carriage; but the length of it is greater, so as to allow for a recoil of several feet after firing.

In a book of elementary fortification, to give any further description of the construction of a traversing platform, would be foreign to the subject.

I shall only observe, that traversing platforms, from the facility which they afford of quickly changing the direction of a gun to the right or left, are peculiarly useful against shipping; and are therefore generally used in towers or batteries erected for the defence of a coast; and on the sea line of maritime fortresses. The gunners are also less exposed in working guns, mounted in this manner, than in any other kind of battery. In works, not directed against the sea, traversing platforms are less common. When few only are used, in a fortress, they are generally placed at the principal salient angles.

CHAP. XIII.

CONSTRUCTION OF THE FINISHED PLAN OF A REGULAR OCTAGON, FORTIFIED ACCORDING TO VAUBAN'S FIRST SYSTEM.—WITH EXPLANATORY REMARKS ON PLAN DRAWING.

The details, which have now been explained, will be sufficient to enable you to understand clearly the finished plan of a regular fortress, many parts of which would otherwise, although in reality simple, have appeared of a very complicated and intricate nature, as was observed in a former chapter.

We shall therefore next proceed to finish the plan of our regular half octagon, of which you have already drawn the outline: but as our former scale, although sufficiently clear for the purpose to which it was then applied, is rather too small to represent properly the detailed parts of a finished plan, we shall commence the whole of our construction anew, on a larger scale.

The plan, for drawing which, rules are now about to be given, will, when finished, correspond with Plate V; to which it will be similar in every respect, excepting that there will, as usual, be some difference between the scale, laid down in the construction, and that of the plate.

1. Draw a margin for your proposed plan, which may be sixteen regular inches by twenty-six.

2. Make a scale of 50 yards to an inch. It is constructed as follows.

Draw a right line eight regular inches long, and divide it into four equal parts.

Subdivide your left division into twenty equal parts, and make every second subdivision more conspicuous than the others.

Under the left extremity of your scale, place the number 100; under the middle subdivision place the number 50; at the end of the first division write the figure 0, and from thence under each of the remaining divisions write successively the numbers 100, 200, and 300.

Each of the small subdivisions at the left of your scale represents a space of 5 yards. They might have been made somewhat smaller, but the present mode of subdivision will be found accurate enough, if carefully used.

For the paragraphs, which ought here to follow, commencing with Nos. 3, 4, 5, &c. and continuing as far as No. 50, inclusive, see the same numbers, in Chap. I.

As a very great multiplicity of lines will be added, in completing the finished plan, the Learner may now, if he thinks proper, pen the scarp lines of his figure, before he proceeds further, which will prevent confusion.

51. In the middle of each of the faces of the reentering places of arms, mark a space of 5 yards for the width of the ramps of the covered way.

52. From the points, thus marked, draw lines about 6 yards long, to represent the sides of the said ramps, in a direction nearly parallel to the adjoining long branches of the covered way. Draw also the top of each ramp.

By this construction, your ramps will be rather oblique to the crest of the glacis, which is intended for the purpose of screening

them, as much as possible, from the observation of an enemy besieging the fortress. Sometimes their parallel sides are curved, so as to gain an oblique direction by degrees.

We shall next proceed to draw the communications across the ditches of our fortress, which we shall suppose, in the center front, to be formed by bridges; but in the remaining fronts, by caponiers.

53. On each side of the original perpendicular of your center front, mark points at the distance of 2½ yards, and through these points draw lines across the main ditch, parallel to the said perpendicular; extending, first, from the curtain to the reverse of the tenail, and secondly, from the front of the tenail to the gorge of the ravelin.

54. At the distance of 40 yards from the salient angle, set off a space of 5 yards, upon the right face of the ravelin of the same front; and from the points, thus marked, draw lines, parallel to each other, perpendicularly across the ditch of the ravelin.

The parallel lines, thus drawn, across the ditches of your center front, are to represent the sides of the bridges, which are supposed to be constructed there.

55. Before the curtain, the tenail, and the right face of the ravelin, of your center front, at the distance of 5 yards from the scarp line of each of these works, and parallel to it, draw lines across your bridges to mark the extent of the drawbridges: and complete your drawbridges in the usual manner, connecting the opposite angles by diagonal lines.

56. Draw lines outwards parallel to the sides of the standing part of each bridge, at as short a distance as is possible, consistently with clearness, in order to denote railing.

This will, at the same time, make the standing part of each bridge appear wider than the drawbridge, which is generally the case, as was before mentioned. *(See Chapter VII, page* 113.)

57. Mark a couple of points, upon the crest of the glacis of the right face of the ravelin of your center front, in the direction of the sides of the bridge produced; and upon the foot of the same portion of the glacis, at the distance of about 5 yards from the adjoining reentering angle, set off also a space of 5 yards.

58. Join each corresponding pair of points, thus marked, nearly opposite to each other, upon the crest and foot of the glacis of your ravelin, by parallel lines, to represent a road of communication leading from the bridges across the glacis; and let the sides of your road be gently curved so as to incline first a little to the left, and afterwards a little to the right, but without any very considerable deviation from a right line.

The outline of the principal communications of your center front is now complete. We shall next draw our proposed caponiers.

59. In all your remaining fronts, on each side of the original perpendiculars of your fortress, mark points at the distance of 5½ yards, and through these points, draw lines parallel to the said perpendiculars, extending across the main ditch, between the tenails and the gorges of your ravelins.

Let these lines represent the crests of the parapets of your caponiers.

60. Parallel to your last drawn lines, draw new lines, outwards, to the right and left, in the same fronts, at the distance of 15½ yards, to show the extent of the glacis of your caponiers.

61. Draw lines across the glacis of each of your caponiers, at the distance of about 5 yards in rear of the gorge of the adjoining ravelin, and parallel to it, in order to show the breadth of the passages, or communications from the advanced extremities of your caponiers, into the main ditch.

Here there is a difference between our construction, and that of

the caponier represented in Chap. VII, page 116, in which two communications or passages are shown, one at each extremity of the work. In our present figure, no communications are supposed to be formed, at the inward extremities of our caponiers, near the tenail.

The outline of our plan, being now finished, we shall next proceed to insert the principal lines of the parapets, ramparts, &c. These must be drawn, all round, parallel to the scarp line of the body of the place, as also to the scarp lines of the tenails and ravelins, in the same manner that you before completed the plan of the simple tenail, which was given in Chap. XI, as an illustration of the Principles of Plan Drawing. In your present drawing, you will make one small difference only; that is, by leaving out the berm of your various works, which is too small to be worthy of notice on a scale of 50 yards to an inch.

In consequence of this omission, the number of lines, which must be drawn parallel to the scarp lines of your present plan, will be one less than the number of parallel lines, that you before drew, in finishing the plan of your simple tenail.

For the respective distances, at which the various parallels required should be drawn, you must refer to the sections of a regular fortress, which you before drew. *(See Chapter I I, and Plate 2d.)*

Commencing with the body of the place, as there represented, you will find, by examining figure 2, that the base of the exterior slope of the parapet of the curtain, including the berm, is 13 feet 6 inches, which is equal to 4½ yards; that of the bastion, shown in figure 1, is 6 inches more; but considering the scale of our present drawing, it is not worth while to notice so small a difference.*

* For the same reason, the projection of the cordon beyond the scarp

You will also find, that the thickness at top of the parapet of the body of the place is 18 feet, or 6 yards, in both figures.

62. In rear of the scarp lines of the body of the place, in your plan, you will therefore set off, successively and in a perpendicular direction, the following distances:

First, 4½ yards for the exterior slope of the parapet;

Secondly, 6 yards for the thickness of the parapet at top,

And through the points, thus marked, draw lines, all round, parallel to the scarp lines of the body of the place.

By referring to your sections a second time, you will find, that the base of the slope of the scarp revetment varies from 5 feet to 5 feet 2 inches, both of which dimensions are rather less than 2 yards; but on our present scale it is scarcely worth while to notice the difference.

63. In front of, and parallel to, the scarp lines of the body of the place, you will therefore draw lines, all round, at the distance of about 2 yards, to show the slope of the scarp revetment.

64. In the extreme bastions, that is to say, in the right and left bastions of your half octagon, draw lines connecting the opposite angles of the flank of each; observing that, in so doing, you will join the corresponding angular points of the interior crest of the parapet, not of the scarp line.

The lines, thus drawn, will represent the gorges of the above bastions.

By referring again to your sections, you will find that the breadth of the terreplein of the body of the place is 39 feet, or 13 yards, in both figures.

lines, and that of the coping in rear of the various counterscarp lines, &c. being only 6 inches each, are a great deal too minute to be noticed in our present plan.

65. In rear of the parapets of all the curtains, and also in rear of the parapets of the two center bastions, of your half octagon, you will therefore draw parallel lines, at the distance of 13 yards, to show the extent of the terreplein; and let such of the said lines, as are drawn parallel to the adjoining curtains, be produced, until they cut the gorges of the two extreme bastions of your figure.

This being done, rub out those parts near the extremities of each gorge, which fall without the points of intersection, thus found.

Refering again to your sections, you will find that the base of the interior slope of the rampart of your curtain, as represented in figure 2, is 16 feet 6 inches, which is equal to 5½ yards: that of the bastion, shown in figure 1, is 1 foot more; but it is not worth while to notice so small a difference in our present plan.

66. In rear of the terreplein of all the curtains, and also of the two center bastions of your half octagon, you will therefore draw parallel lines, all round, at the distance of 5½ yards, in order to show the extent of the interior slope of the rampart of these works.

The nature of the ridges and furrows, which are always formed by the meeting of slopes, and of which there will be a very great number in your present plan, has been already so fully explained in our former constructions, that you can be at no loss as to the proper places for inserting them. You will therefore, when any part of your plan is completely finished, recollect to draw lines, to represent the said ridges and furrows, without waiting for any further directions to that effect.

REMARK.

If you now examine your two center bastions, you will find, that a considerable space is left, in the interior of each, which is supposed to remain on the natural level of the original ground; whilst the ramparts, which inclose the above space on every side

excepting towards the rear, are raised considerably above that level.

Consequently, a bastion, thus constructed, either when viewed from the ramparts, or as it appears in a model, resembles a kind of bason, presenting a great hollow or empty space in the interior of it.

Such bastions are therefore called EMPTY BASTIONS.

Sometimes, instead of being left hollow, in the above-described manner, the whole of the interior of a bastion is filled up with earth and rubbish, to the same height nearly, that is usually given to the terreplein of an empty bastion.

A bastion thus constructed, so that the whole of the interior of it forms one continued terreplein, is called A FULL BASTION.

Having made these remarks, we shall proceed with our construction, drawing next the ramps of the body of the place, and first those of the extreme bastions of our half octagon, which we shall suppose to be full bastions.

It may perhaps be almost superfluous to recommend the Learner, if he finds any difficulty in the construction of his ramps, as laid down in the following paragraphs, to go back to Chapter VIII, and study the first part of it with greater attention.

We shall suppose that two ramps, each 38¼ yards long, are to be formed in our proposed full bastions, and that the tops of the exterior sides of these ramps are to agree with the extremities of the gorges of the said bastions.

67. From the extremities of the gorges of your extreme bastions, as centers, with a radius of 38¼ yards, you will therefore make intersections, upon the bottom of the interior slope of the rampart of the adjoining curtains.

Each of the new points thus found will show the foot of an exterior side of one of your ramps.

68. Draw the exterior sides of your ramps, accordingly, by connecting the proper points.

69. Make your ramps 5 yards wide; and draw the top, and bottom, and interior side of each, accordingly.

70. Let the interior slope of each ramp have a base or breadth of 5½ yards at top, which is equal to that of the interior slope of the rampart; from thence let it fall away to nothing at bottom; and draw the interior slopes of your ramps accordingly, representing each of them by a triangle, in the usual manner.

71. Connect each pair of ramps by a right line drawn between the tops of the interior sides.

The last drawn lines are to represent the back of the terreplein of your full bastions, and, if correctly drawn, will be parallel to the former gorges, which may now be rubbed out, being of no further use in the construction.

72. Represent the interior slope of the rampart of each of your full bastions, by drawing lines at the distance of 5½ yards, in rear of the last drawn lines, and parallel to them.

The general form of your two full bastions and of their ramps being now complete, we shall next proceed to draw the ramps in the empty bastions, commencing with those of the flanks.

Let the foot of the exterior side of each of these ramps agree with the inward extremity of the bottom of the interior slope of the rampart of the flank, in which it is to be constructed.

73. From the above points, therefore, in your two empty bastions, as centers, with a radius of 38½ yards, make intersections upon the back of the terreplein of your flanks, in order to find the top of the exterior sides of your proposed ramps; and draw the said exterior sides accordingly.

74. Complete the form of your ramps, making them 5 yards wide. Draw also the interior slope of each ramp, in the usual manner, making it 5½ yards wide at top, and from thence falling away to nothing at bottom.

75. Connect, by a right line, the top of the interior side of the ramp of every flank, and that extremity of the back of the terreplein of the same flank, which is in rear of the angle of the shoulder.

The lines, thus drawn, will represent the new form, which is to be given to the back of the terreplein of every flank, after the ramps are constructed. Consequently the former lines, which represented it, will become imaginary lines, and may be rubbed out.

76. In rear of the last drawn lines, and parallel to them, draw lines at the distance of 5½ yards, to represent the bottom of the interior slope of the rampart of each flank, in its new form; for if any change is made in the terreplein of a work, it follows, as a matter of course, that the interior slope of the rampart must also be altered.

The general form of the flanks of your empty bastions, and of their ramps, being now complete, we shall next draw the ramps in the faces of the same bastions.

77. On those lines, which represent the back of the terreplein of the two faces of each empty bastion, from their common intersection or angular point, set off 15 yards each way.

78. From the point, thus marked, on each face, as a center, with a radius of 41 yards, make an intersection upon the bottom of the interior slope of the rampart of the same face.

Let the former set of points, thus marked on the faces, show the position of the top; let the latter show the position of the foot, of the several exterior sides of your proposed ramps.

79. Draw the said exterior sides accordingly, by joining the proper points: complete the form of your ramps, making them

5 yards wide; and draw the interior slope of each ramp, in the usual manner, making it 5½ yards wide at top, and from thence falling away to nothing at bottom.

80. Produce those perpendiculars, which represent the top of each pair of ramps inwards, as far as the capital of the bastion, where they will meet.

81. From these points of intersection, as centers, describe small arcs, connecting the top of the interior sides of each pair of ramps.

82. From the same points, as centers, but with a radius 5½ yards shorter (*this being equal to the interior slope of the rampart*), describe new arcs connecting the extremities of those lines, which represent the bottom of the interior slope of each pair of ramps.

The arcs, thus drawn, in each empty bastion, represent the new form, which is supposed to be given to the terreplein and interior slope of the rampart, in consequence of the formation of the ramps.

The general form of the body of the place is now complete, including the whole of its ramps, which have been constructed with a slope, whose base is every where in the proportion of seven times the height nearly.*

By again referring to your sections, you will find that the base of the interior slope of all the parapets is in the proportion of one third of its height; and that in those parts, where there is a banquette, there is a height of 4 feet 4 inches only, and consequently

* The height of the terreplein of the flanks and curtains being 16½ feet or 5½ yards in rear, the ramps of the full bastions, and of the flanks of the empty ones, are made 38½ yards long, which is exactly seven times the above height. The terreplein of the faces of the bastions being supposed to be about 1 foot higher, the length of the ramps is there increased to 41 yards, which preserves the same proportion nearly.

the base of the slope must there be 1 foot 5⅓ inches, which is one third of the above height; that is to say, the base of the interior slope of the parapet is, in such places, very nearly equal to half a yard.

But in those parts, where there is no banquette, as for instance wherever gun batteries are supposed to be established; the base of the interior slope of the parapet will be 2 feet 6 inches, which is not quite equal to one yard.

We are now about to draw the interior slope of the parapets of the body of the place; and as it is proposed, in some parts to represent a banquette, in others gun batteries; therefore, strictly speaking, in some parts of our figure, ½ yard, in others about 1 yard, ought to be set off for the extent of the said interior slope. The former dimension is however so small, that it would be better to leave it out entirely, than to attempt introducing it in a plan drawn upon our present scale: we shall therefore take no notice of the difference, but make the interior slope of the parapets of all our works, nearly 1 yard wide, everywhere.

REMARK.

I shall here remark, that, generally speaking, in finished plans of fortification, it is usual, whenever a similar case occurs, either to omit the minuter parts of the work altogether, as we have done, in our present plan, in respect to the whole of our berms; or to give them, for the sake of clearness, rather more than their actual dimensions, as we did in respect to the railing of our bridges. This, it must be evident, could not have been represented, in its true dimensions, on a scale of 50 feet to an inch; for the strongest scantling, likely to be used for that purpose, would probably be less than 1 foot wide. If we had begun our finished plan on a much smaller scale than our present one, it might then have been

necessary to omit the interior slope of the parapets altogether, and to enlarge some of the other slopes, &c. considerably beyond their actual proportions, which, as we are now proceeding, we shall be able to represent accurately.

These irregularities, which are always to be met with, do not detract from the accuracy of a general plan of fortification; it being well understood, that such a plan is not expected to explain all the smaller details of the various works represented.

In like manner, in civil drawings, the general plan, elevations, and sections of a great edifice, point out the principal dimensions only. so that although the beauty and merit of the design of the Architect may be judged of by examining them, they do not enter into the minuter details of the work. To explain these, rough plans, in outline, of such particular parts as require it, are drawn up for the use of the artificers employed; and these working plans, as they are called, are equally necessary in works of fortification.

Having made this remark, we shall continue our construction.

83. In rear of the interior crest of the parapet of the body of the place, draw parallel lines, all round, at the distance of rather less than 1 yard, to show the interior slope of the parapet.

We shall next draw embrasures, in various parts, to represent the position of gun batteries, which may be established on the ramparts of the body of the place; and for the general dimensions, which ought to be observed, in this part of your construction, I shall refer you to the plan and sections of the field battery, which you have already drawn. *(See Chap. X, and Plates 3 and 4.)*

There you will find, that the sills of the embrasures do not exactly agree with the bottom of the interior slope of the parapet,

but stand some inches more to the front. In our present plan we shall, however, suppose them to agree, in consequence of the smallness of the scale.

Reducing the dimensions of the embrasures, as represented in the plan alluded to, from feet to yards, in order to suit our present scale; it will appear that they must be made rather less than 1 yard wide in rear, but about 4⅓ yards wide in front; and that the front or mouth of each embrasure must be drawn in front of the exterior crest of the parapet, and parallel to it, at the distance of about 1 or 1⅓ yard.

You will also find that the embrasures of a gun battery must be placed at intervals of 6 yards apart, measuring from center to center.

Keeping these particulars in mind, you will draw the proposed gun batteries in the body of the place of your half octagon as follows; observing, that whatever distance shall be pointed out for the position of the center of the first embrasure of each battery, must be measured upon the interior crest of the parapet, not on the scarp line.

84. In each of your flanks, draw a battery of 5 guns; let the center of the embrasure of the first gun be placed at the distance of 14 yards from the angle of the flank; and, in drawing your embrasures, let the line of fire of each oblique a little outwards, so that they shall see not only the main ditch, but also the covered way and glacis in front of the faces of the opposite bastions.

By this construction, there will be a small variation between the direction of your present embrasures, and those of your field battery, in which every line of fire was made exactly perpendicular to the parapet.

85. In each of the faces of your empty bastions, draw a battery of 3 guns, placing the center of the first embrasure at the distance of 14 yards from the angle of the shoulder; and let the line of

fire of your embrasures be laid out a little obliquely, so that they shall see the ditches of the opposite faces of the ravelins, as also the covered way and a part of the glacis in front of the said faces.

86. In each of the faces of your full bastions draw a battery of 5 guns, placing the center of the first embrasure also at the distance of 14 yards from the angle of the shoulder; and attending to the same rule, prescribed in your last drawn batteries, as far as regards the direction of the two first embrasures. In the three remaining embrasures of each of these new batteries, you may lay out the line of fire perpendicularly, or nearly so.

87. In each of the faces of your empty bastions, you will draw a second battery for 5 guns, in addition to the three-gun battery which is already represented there.

Place the center of the first embrasure of each of these new batteries, at the distance of 55 yards from the angle of the shoulder, and let the line of fire of the embrasures in general be laid out perpendicularly, or nearly so.

88. Towards each extremity of the curtain of your center front, draw a battery for 3 guns, placing the center of the extreme embrasure of each of these batteries at the distance of 40 yards from the adjoining extremity of the curtain; and make the line of fire of your embrasures rather oblique, so as to bear well upon the interior of the opposite ravelin.

Gun batteries might also be represented in our remaining curtains; and it will be understood that embrasures are not limited as to their position, but may be opened in any part of the parapets of a fortress, which is judged most convenient: we shall not, however, draw any more embrasures in the body of the place of our present figure, as they might make it appear confused.

Nor shall we represent any mortar batteries in our present plan, it being sufficient here to remark, that they may be established upon any part of the terrepleins of the various works, that is

judged proper; observing, however, that the platforms must be placed some feet further in rear of the parapet, than is necessary in a field battery, in order that they may not interfere with the banquettes of the fortress, which are essential towards its defence.

Mortar batteries, if introduced in a plan drawn on our present scale, would be denoted by small circles, drawn a little in rear of the slope of the banquette, at the distance of about 5 yards apart, in the manner before explained, in treating of batteries. (*See Chap. IX, page* 154.)

Having made these remarks, we shall next proceed to represent the barbet batteries, which we shall suppose to be established in our full bastions.

89. In rear of the salient angle of each of your full bastions, set off 22 yards from the angular point, each way, upon the bottom of the interior slope of the parapet, for the extent of the front of your barbets; and draw the terrepleins of each barbet, making them 8 yards wide, with perpendicular extremities.

But before we finish these works, it will be necessary previously to insert the adjoining banquettes, without which the ramps and slopes of our barbets cannot well be drawn.

Instead, however, of confining ourselves to those portions only, of the banquettes of the body of the place, which are now more immediately required, for the above-mentioned purpose; it will be most convenient to lay out the whole of them at once; and it was before stated, that where gun batteries are represented, no banquettes must be drawn.

90. At the distance of about 1½ or 2 yards, from the center of the first and last embrasures of each of the former gun batteries of the body of the place, you will therefore mark points, outwards, upon the bottom of the interior slope of the parapet.

These points are to show the extremity of each battery; beyond which, no part of the banquette is supposed to be continued.

By referring again to your sections, you will find, that in all your works, excepting the covered way, the breadth of the banquette is 4 feet, which is not quite 1⅓ yard; and that the base of the slope of each banquette is rather less than 6 feet 6 inches, that is to say, very little more than 2 yards.

91. In rear of the whole of the parapets of the body of the place, excepting those parts where the gun batteries and barbets are marked, you will therefore draw parallel lines, all round, at the distance of 1⅓ yard nearly, to show the tread of the banquette; in rear of which, draw a second set of parallel lines, at the distance of about 2 yards, or a little more, in order to show the slope of the banquette, of the body of the place.

92. From the points, marked for the extremities of your gun batteries, draw right lines, backwards, not exactly perpendicular to the parapet, but with a moderate splay outwards, in order to represent the extremities of the broken portions of the banquette of the body of the place.

These extremities may be supposed to be formed with a slope, and therefore, according to the principles of plan drawing, they ought to be represented in our plan, by figures resembling sections of the work itself.

93. At the extremity of each of the broken portions of your banquette, you will draw small figures resembling sections of the banquette accordingly.

This being done, the whole of the banquettes of the body of the place will be complete. It is, however, to be observed, that even in those parts of a fortress, where gun batteries are established, small portions of banquette are often constructed, in rear of the merlons, between the adjoining platforms. As the embrasures are 6 yards apart, and the platforms only 3 yards wide in front, there will of course remain a space of 3 yards for the base of the said banquettes; but by reason of the splay of the

embrasure, and of the slope usually allowed at each extremity of the banquette itself, the length of them may be diminished to less than 2 yards at top. Such small portions of banquette, although useful, and, as before observed, often executed in practice, are seldom or never represented in a general plan, where they would appear too minute.*

Having made this remark, we shall now return to our barbets, the ramps of which must next be represented.

94. On each extremity of your barbets, mark points for the tops of the exterior sides of your proposed ramps, half way up the slope of the adjoining banquette; and from each of these points, as a center, with a radius of 10 yards, make an intersection upon the bottom of the above-mentioned slope, in order to show the position of the foot of the exterior side of each ramp.

95. Draw the exterior sides of the ramps of your barbets accordingly, by joining the proper points; and complete the form of the said ramps, making them 4 yards broad. (*See Chap. XII.*)

96. Draw parallel lines, to show the extent of the reverse slope of your ramps, at the distance of 5 feet; that is to say, at the dis-

* Even in the field, it is usual to make small banquettes behind the merlons of a gun battery, and behind the parapets of a mortar battery, in any place not immediately in front of the platforms. These however are merely intended as small look-out stations for men to stand upon, in order to watch the enemy's movements, as also to observe the effect of the fire of their own battery. Consequently they are not made so high, nor so large in any way, nor with such a convenient slope, as those portions of banquette which are constructed behind the merlons of a regular fortress. Nor indeed is their form of any consequence whatever, provided there is room for one or two men to stand conveniently and see over the parapet. Such being the case, it was not thought worth while to represent them, in the plan and sections of our field battery.

tance of rather less than 2 yards; the above being supposed to be equal to the height of the barbet nearly.

97. Draw lines across the tread of your banquette, parallel to the extremities of your barbets, at the distance of rather less than 1 yard, in order to represent the slope of the adjoining part of each of the said extremities, which is supposed to be equal to its height.*

98. Draw the interior slope of each of the ramps of your barbets, making it equal, at top, to the reverse slope of the barbet itself; and from thence gradually falling away to nothing at bottom.

99. Draw also the exterior slope of each of these ramps, making it equal, at top, to the slope of the adjoining part of the extremity of the barbet; and from thence falling away to nothing at bottom.

Your barbets are now finished, which being supposed to be about 5 feet high, and their ramps 10 yards long, the latter are consequently constructed with a slope, whose base is in the proportion of six times the height.

The two barbets, which you have just drawn, will be sufficient to explain the manner in which these works are represented in a finished plan of fortification; and therefore we shall not introduce any more of them in our present half octagon. It will, however, be understood, that barbets are not limited in their position, but may be constructed behind any part of the parapets of the body of the place, as also behind any part of the parapets of the ravelins and other outworks, which may be judged proper, although the salient angles are usually preferred.

* The banquettes of the fortress are 3 feet 2 inches high, as will be seen by referring to the sections; and the barbets are supposed to be 5 feet high. The difference between these dimensions, which is 1 foot 10 inches, will therefore show the height of the slope of the extremity of the barbet; the base of which slope is supposed to be the same, but on so small a scale we cannot make it much less than 1 yard, in our plan.

The body of the place of our half octagon being now complete, we shall next proceed to finish our ravelins.

By referring again to the second figure of your sections, you will find, that the base of the scarp revetment of your ravelin is 5 feet, or rather less than 2 yards: that the exterior slope of the parapet of your ravelin, including the berm, is 11 feet, or 3⅔ yards; that the terreplein of the ravelin is 30 feet, or 10 yards broad; that the base of the interior slope of the rampart of the ravelin is 12 feet, or 4 yards; and that the thickness at top, and interior slope, of the parapet of the ravelin, as also the dimensions of the banquette of that work, are the same as those of the body of the place.

100. In front, therefore, of the scarp lines of your ravelins, you will set off about 2 yards, perpendicularly, for the slope of the scarp revetment.

And in rear of the scarp lines of your ravelins, you will set off, successively and perpendicularly, the following distances;

First, 3⅔ yards for the exterior slope of the parapet;

Secondly, 6 yards for the thickness of the parapet at top;

Thirdly, 10 yards for the breadth of the terreplein;

Fourthly. 4 yards for the interior slope of the rampart;

And through the various points, thus marked, draw lines, all round, parallel to the scarp lines of your ravelins.

101. In rear of the interior crest of the parapets of your ravelins, draw parallel lines, all round, at the distance of rather less than 1 yard, to represent the interior slope of the parapets.

By referring again to your section, you will further find, that the base of the slope of the gorge revetment of your ravelin is 3½ feet, which is rather more than 1 yard.

102. In rear of the demigorges, and break at the gorge, of each ravelin, you will therefore draw parallel lines, all round,

at the distance of about 1 yard, to show the slope of the gorge revetments of your ravelins.

103. In the right face of your center ravelin, produce backwards those lines which represent the sides of the drawbridge, as far as the bottom of the interior slope of the rampart of that face.

104. The lines, thus produced, are to represent the sides of an open gateway or communication, supposed to be cut entirely through the rampart of the right face of the center ravelin of your figure. The whole of the parallel lines, which intersect the said communication, must therefore be rubbed out, excepting that which forms a part of the original scarp line. This is left, because it agrees with and represents the back of the drawbridge; and therefore, in afterwards penning your drawing, you must recollect to mark it black.

We shall next draw embrasures, to represent the position of gun batteries, which may be established on the ramparts of our ravelins.

105. In each of the faces of your ravelins, excepting that where the bridge is represented, draw a battery of 3 guns, in the usual manner, placing the center of the first embrasure at the distance of 20 yards from the salient angle; and laying out the line of fire of your embrasures, perpendicularly, or nearly so.

106. In each of the faces of your ravelins, excepting as before that where the bridge is represented, draw a second battery of 3 guns, placing the center of the first embrasure at the distance of 55 yards from the salient angle; and laying out the line of fire of these embrasures obliquely, so as to bear not only upon the opposite reentering places of arms, but also upon the branches of the covered way of the adjoining bastions.

107. In the left portion of the right face of the ravelin of your center front, draw a battery of 2 guns, placing the center of the first embrasure at the distance of 8 yards from the adjoining side

of the open gateway there represented; and let the line of fire of your embrasures be perpendicular, or nearly so.

108. In the right portion of the right face of the ravelin of your center front, draw a battery of 4 guns, placing the center of the first embrasure at the distance of 8 yards from the adjoining side of the said communication: let the line of fire of the two first guns of this new battery be directed upon the road of communication, which is cut across the glacis; and let the line of fire of the remaining guns be laid out, so as to bear not only upon the opposite reentering place of arms, but also on the adjoining branch of the covered way, of the right demibastion of the same front.

109. In rear of the whole of the parapets of your ravelins, excepting those parts where the batteries and gateway are marked, draw parallel lines, all round, at the distance of about 1½ yard, to represent the tread of the banquette; in rear of which, draw a second set of parallel lines, at the distance of about 2 yards, to show the slope of the banquette.

110. At the distance of 1½ or 2 yards, from the center of the extreme embrasures of each battery, draw lines from the bottom of the interior slope of the parapet, backwards, in order to represent the extremities of the broken portions of the banquettes of your ravelins: let these lines have a moderate splay outwards; and complete the form of each of the said extremities, in the usual manner, by drawing small figures resembling sections of the banquette.

The form of the banquettes of our ravelins is now complete. We shall next draw their ramps; and as the height of the terreplein of the ravelins is 12 feet, or 4 yards, according to the section, we may make our ramps 28 yards long, which will give them a slope, whose base is in the proportion of seven times the height.

111. On those lines which represent the back of the terreplein of the faces of your ravelins, from their common intersection or

angular point, set off 10 yards each way, excepting in the right face of the ravelin of your center front only.

112. From the points, thus marked in the faces of your ravelins, as centers, with a radius of 28 yards, make intersections upon the bottom of the interior slope of the rampart of the same faces.

These new points are to mark the foot, whilst the former set of points were to mark the top, of the exterior sides of the ramps of your ravelins.

113. Draw the exterior sides of your ramps accordingly, by joining the proper points; and complete the form of the ramps of your ravelins, in the usual manner, making them 5 yards wide.

114. Draw the interior slope of each of the ramps of your ravelins, making it 4 yards wide at top, which is equal to the interior slope of the rampart of the ravelin, and from thence let it fall away to nothing at bottom.

In drawing these slopes, the top of each ramp will necessarily be produced, inwards, to the distance of 4 yards; and in each adjoining pair of ramps, these produced lines, if correctly drawn, will meet each other in the capitals of the ravelins.

115. In all your ravelins, excepting that of your center front, from that point in the capital of each, as a center, which is intersected by the above produced lines, describe an arc connecting the tops of the interior sides of the adjoining ramps.

These arcs will represent the new form, which is supposed to be given to the back of the terreplein of the above ravelins, in consequence of the construction of the ramps.

116. In the left face of your center ravelin, rub out the whole of that part of the original interior slope of the parapet, which is beyond the top of the ramp represented there; and produce the interior side of the said ramp, outwards, until it meets the back of the terreplein of the right face of the same ravelin.

117. Bisect the angle, which is formed by the above lines, namely by the interior side of the ramp of your center ravelin pro-

duced, and the back of the terreplein of the right face of that work: and produce backwards the top of the above ramp, until it meets the said bisecting line.

118. From the point of intersection, thus found, as a center, describe an arc, commencing at the top of the interior side of the ramp of your center ravelin, which you will continue, until it meets the back of the terreplein of the right face of that work.

119. From the same point, as a center, but with a radius 4 yards shorter *(this being equal to the interior slope of the rampart of the ravelin)*, describe a second arc, connecting the adjoining extremity of that line, which represents the bottom of the interior slope of your ramp, to that which represents the bottom of the interior slope of the rampart of the right face of the ravelin.

The arcs, thus drawn, in your center ravelin, represent the new form which is supposed to be given to part of the terreplein and interior slope of the rampart, in rear of the salient angle, in consequence of the construction of the ramp.

A new ramp must next be drawn in the same ravelin, for the purpose of ascending to that part of the terreplein, which is to the right of the gateway; but as there is not room there for a ramp equal in extent to the former ones, the length of the new ramp proposed must be diminished to 20 yards, the slope of which will be in the proportion of five times its height only.

120. Upon the bottom of the interior slope of the rampart of the right face of your center ravelin, at the distance of 4 yards to the right of the gateway, mark a point, to show the position of the foot of the exterior side of your proposed ramp. And from the above point, as a center, with a radius of 20 yards, make an intersection on the back of the terreplein of the same face, in order to show the position of the top of the said exterior side.

121. Draw the exterior side of your ramp accordingly, by con- the points, thus marked; complete the form of your ramp usual manner, making it 5 yards broad; and rub out the

whole of that part of the interior slope of the right face of your ravelin, which is beyond the top of the said ramp.

122. Draw the interior slope of your ramp, making it 4 yards wide at top, which is equal to the interior slope of the rampart of the ravelin, and from thence falling away to nothing at bottom.

123. Produce the interior side of your ramp as far as the right demigorge of your ravelin, in rear of which produced line, and parallel to it, draw a second line at the distance of 4 yards.

These two lines will represent the new form, which is supposed to be given to a part of the terreplein, and interior slope of the rampart of the right face of the center ravelin of your figure, in consequence of the construction of your last drawn ramp.

We shall suppose the extremities of all our ravelins, as also the sides of the gateway, in our center ravelin, to be reveted, with a slope of about one sixth of the height.

124. At each extremity of the ramparts of your ravelins, you will therefore draw a figure resembling a distorted section of the ravelin itself; making the said figures, however, for the sake of clearness, rather larger than, strictly speaking, the above-mentioned slope of one sixth ought to permit.

125. At the extremity of each broken portion of the right face of your center ravelin, you will also draw a figure resembling a distorted section of the rampart of the ravelin, making it, for the same reason, rather larger than its actual dimensions are supposed to be.

The ravelins of our fortress being now complete, we shall next finish our tenails.

By referring again to the second figure of your sections, you will find, that the base of the scarp revetment of your tenail is 3 feet or 1 yard; that the base of the exterior slope of the parapet, including the berm, is 4 feet 6 inches, or 1½ yard; that the remaining dimensions of the parapet and banquette of the tenail are equal

to those of the body of the place and ravelins; and that the base of the gorge revetment of the tenail is 2 feet 9 inches, which is rather less than 1 yard.

126. In front, therefore, of the scarp lines of your tenails, you will set off 1 yard, perpendicularly, for the slope of the scarp revetment.

And in rear of the scarp lines of your tenails, you will set off, successively and perpendicularly, the following distances;

First, 1½ yard for the exterior slope of the parapet;

Secondly, 6 yards for the thickness of the parapet at top;

Thirdly, rather less than 1 yard for the interior slope of the parapet;

Fourthly, about 1½ yard for the tread of the banquette;

Fifthly, about 2 yards for the slope of the banquette;

Lastly, in rear of the reverse lines of your tenails, set off rather less than 1 yard for the slope of the gorge revetments;

And through the various points, thus marked, draw lines, all round, parallel to the scarp lines of your tenails.

127. In the curtain of your center tenail produce backwards those lines, which represent the sides of the adjoining drawbridge, as far as the bottom of the slope of the banquette.

The lines, thus produced, are to represent the sides of an open gateway or communication, supposed to be cut entirely through the parapet of the curtain of your center tenail. The whole of the parallel lines, before drawn, which intersect the said communication, must therefore be rubbed out, excepting that which agrees with the back of the drawbridge.

We shall suppose the extremities of all our tenails, as also the sides of the gateway in our center tenail, to be reveted, with a slope of about one sixth of the height.

128. At each extremity of the tenails, represented in your plan, you will therefore draw a figure resembling a distorted section of the tenail itself; making the said figures, however, for the sake of

clearness, rather larger than, speaking, the above-mentioned slope of one sixth ought to

129. And on each side of the gateway represented in the curtain of your center tenail, you will, in like manner draw a figure resembling a disproportioned section of the parapet and banquette of the tenail; also enlarging these new figures, like the former ones, somewhat beyond their just dimensions, and for the same reason.

This being done, your tenails will be complete. We shall next proceed to finish our counterscarps and covered way.

By referring again to your sections, you will find, that the base of the slope of your counterscarp revetments varies from 3 feet 6 inches, to 3 feet 8 inches, neither of which dimensions is much more than 1 yard.

130. In rear, therefore, of the various counterscarp lines of your fortress, draw lines parallel to them, at the distance of rather more than 1 yard, in order to represent the slope of the counterscarp revetments.

131. In rear of the crest of your glacis, you will next draw parallel lines all round, at the distance of rather less than 1 yard, in order to represent the interior slope of the parapet of the covered way.*

132. Let each side of the ramps in the reentering places of arms have a slope, at bottom, equal to the interior slope of the parapet of the covered way; and from thence falling away to nothing at top; and draw the slopes of the said ramps accordingly.

133. In like manner, in the communication, represented across the glacis of your center ravelin, let each side of the road have a

* As part of the covered way only will be formed with banquettes, the same remarks here apply, that were before used, in treating of the interior slope of the parapet of the body of the place. (See page 234.)

slope, in rear, equal to the interior slope of the parapet of the covered way; but from thence falling away to nothing in front; and draw the said slopes accordingly.

Before we draw the banquettes of the covered way, it will be proper to finish the traverses. We shall suppose that they are of the same interior height as the crest of the glacis nearly, that is from 7 feet 6 inches to 8 feet. If we further suppose, that the traverses have a dip of one sixth of their thickness at top; then the exterior height and slope of each will be about 1¼ yard, or a little more. The banquettes of the traverses, as well as those of the covered way, are supposed to be 1 foot wider than our former banquettes, because a part of them is occupied by a row of palisades; but on our present scale, it is scarcely worth while to notice the difference.

134. *In front of* each of your traverses, you will therefore set off, perpendicularly, about 1¼ yard for the exterior slope; and in rear of each traverse set off, successively and perpendicularly, the following distances;

First, rather less than 1 yard for the interior slope of the traverse;

Secondly, about 1½ yard for the banquette;

Thirdly, about 2 yards for the slope of the banquette;

And through the various points, thus marked, draw lines parallel to the front or back of each traverse.

135. From the outward extremity of each traverse, in rear of the interior crest of it, draw a right line to show the extremity of the banquette of the traverse; and let these lines oblique backwards towards the covered way, with a moderate splay, in order to give more room for the passage.

136. At the inward extremity of each traverse, draw a small figure resembling a disproportioned section of the traverse; and

rub out those parts of your original counterscarp lines, which interfere with the said figures.

137. At the outward extremity of each traverse, draw also a small figure, resembling a distorted section of the same; but in order to give more room for the adjoining passage, round off both angles of it, in the manner explained in a former chapter of this work. (*See Chap. XI, page 202.*)

This being done, the new figures, thus drawn, will not, like the former ones, represent the whole of the lines which ought to appear in a section of the traverse, but will be imperfect at the angles.

We shall next draw the banquettes of the covered way, observing however that none must be represented opposite to the outward extremities of the traverses; because the banquette could not be continued in these portions of the covered way, without blocking up the necessary passages. The road of communication and the ramps in the reentering place of arms, must also of course be left free.

138. In rear of the whole of the crest of the glacis, excepting the above-mentioned portions of it only, you will therefore draw parallel lines, all round, at the distance of about 1½ yard from the bottom of the interior slope of the parapet, in order to represent the tread of the banquette; in rear of which draw a second set of parallel lines, at the distance of about 2 yards, to show the slope of the banquette of the covered way.

The extremities of the broken portions of the banquettes of your covered way must next be represented, which must be done in the same manner as those of your former banquettes.

139. Draw right lines to represent the extremities of the various broken portions of the banquettes of your covered way accordingly. Let a part of these lines be drawn from the inward extremity of each of those small breaks in the crest of the glacis, which represent the front of the passages of the traverses. Let a part of them be drawn from the inward extremities of the sides of the road

of communication, and ramps of the covered way. Let the remainder of them be drawn at such a distance from the rear of each traverse, as to leave a clear passage of about 3½ or 4 yards in the narrowest part. And let the whole of them have a moderate splay outwards.

140. This being done, complete the form of the said extremities, in the usual manner, by drawing small figures resembling sections of the banquette.

The whole of the covered way being now complete, we shall next finish our caponiers, and bridges, which at present appear in outline only.

141. From the crests of the parapets of all your caponiers, set off, successively and perpendicularly, the following distances, inwards;

First, rather less than 1 yard for the interior slope of the parapet;

Secondly, about 1¼ yard for the banquette;

Thirdly, about 2 yards for the slope of the banquette;

And through the various points, thus marked, draw lines parallel to the crests of the parapets of your caponiers.

We shall suppose the outward or advanced extremities of our caponiers to be reveted with a slope of about one sixth.

142. You will therefore complete the form of the said extremities, in the usual manner, by drawing small figures resembling disproportioned sections of the caponier, which, for the sake of clearness, you may make a little larger than their just proportion.

Strictly speaking, small figures, resembling disproportioned sections, ought also to be drawn at the inward extremities of the caponiers, because they terminate upon the scarp revetment of the tenail, which is a sloping surface. But we shall not represent the said figures in our present plan, nor are they ever represented in

general plans of fortification, because, unless the scale were a great deal larger than 50 yards to an inch, which in such plans is not usual, the small sections, alluded to, could not be marked upon that space, which represents the slope of the scarp revetment of the tenail, without creating confusion. In a detailed plan, drawn on a very large scale, and representing a small portion of a fortress, such as, for instance, the tenail, caponier, and gorge of the ravelin, only, they might, however, be introduced with propriety.

Our caponiers being therefore finished, as far as is judged necessary; we shall next proceed to complete our bridges.

143. Across the standing part of each of the bridges, which appear in your center front, draw perpendiculars to represent planks, placing the said planks as near to each other as is possible, without creating confusion.

144. Produce the sides of the first plank of each bridge, that is to say, of that plank which is immediately in front of the draw-bridge, about 1 yard each way, to the right and left, beyond the sides of the railing; and join the extremities of these produced lines by short perpendiculars.

You have now, in all your bridges, formed two small rectangles, one on each side beyond the railing. These are to represent the ends of one of the piers or beams, by which the bridge is supported. The remaining piers or beams, all of which are supposed to be placed at equal intervals from each other, must next be drawn.

145. For this purpose, divide the standing part of the bridge, which extends from the curtain to the tenail, into two equal parts;

Divide the standing part of the bridge, which extends from the tenail to the ravelin, into ten equal parts;

Divide the standing part of the bridge, which extends from the ravelin to the covered way, into three equal parts:

And opposite to the various points of division, thus found, draw small rectangles, equal to the former, on both sides of each

bridge, in order to represent the remainder of the piers or beams, which were to be drawn.

In a wooden bridge, any part or division of it, which is supported by two adjoining piers, is called A BAY OF THE BRIDGE.

The bridges of our fortress being now complete, we shall next proceed to draw the various staircases, and first the staircases of communication in the reverse of the several works.

146. Upon the bottom of the slope of the gorge revetment of each of your tenails, excepting that of the center front of your half octagon, mark a space of 5 yards, exactly in the middle of the small curtain, in order to show the breadth of the landing place of a proposed double staircase. (*See Chapter VIII, page* 138.)

147. From the points, thus marked, as centers, with a radius of 6 yards, make intersections upon the original gorge lines of your tenail, that is to say, upon those lines which represent the top of the slope of the gorge revetment. Let the new points, thus found, show the position of the top of the interior sides of your proposed double staircases; and draw the said interior sides accordingly.

148. Make your staircases 2 yards broad: and draw the top, and bottom, and exterior side of each.

149. Connect the top and bottom of each pair of exterior sides by right lines, in order to show the slope of the revetment of your double staircases.

150. Draw perpendiculars across each staircase, to represent steps, as near to each other as is possible, consistently with clearness.

This being done, the staircases in the reverse of our tenails will be complete. We shall next draw those of our ravelins.

151. In the middle of the break at the gorge of each of your ravelins, excepting that of the center front of your half octagon,

set off a space of 5 yards, upon the bottom of the revetment, in order to show the breadth of the landing place of a proposed double staircase.

152. From the points, thus marked, as centers, with a radius of 10 yards, make intersections upon the original gorge lines of your ravelins, that is to say, upon those lines which represent the top of the slope of the gorge revetment. Let the new lines, thus found, show the position of the top of the interior sides of your proposed double staircases, and draw the said interior sides accordingly.

153. Make your staircases 2 yards broad; and draw the top and bottom, and exterior side of each.

154. Connect the top and bottom of each pair of exterior sides by right lines, to show the slope of the revetment of your double staircases, and draw perpendiculars to represent steps, in the usual manner.

This being done, the staircases in the reverse of our ravelins will be complete. We shall next draw those of the covered way, commencing with the staircases of the salient places of arms.

155. In the middle of each of the circular parts or salients of your counterscarp, set off a space of 5 yards upon the bottom of the slope of the revetment, in order to show the breadth of the landing place of a proposed double staircase.*

156. From the points, thus marked, as centers, with a radius of 10 yards, make intersections upon the original counterscarp lines of your plan, that is to say, upon those lines which represent the top of the slope of the revetments, in order to show the position of the top of the interior sides of your proposed double staircases.

* This of course implies, that one half of the breadth of the landing places will be set off to the right, the other half to the left, of the capitals of the salient places of arms.

157. Draw the said interior sides accordingly, by connecting the proper points on the top and bottom of the slope of the counterscarp revetment; but as the counterscarp is built there in a circular form, the points alluded to must be connected by curved lines, not by right lines, as in your former constructions.

158. Complete the form of your staircases, making them 2 yards broad, and representing the exterior sides of them by curves, drawn parallel to the interior sides, at the above distance; but marking the top and bottom of each by perpendiculars, in the usual manner.

159. Connect the top and bottom of each pair of exterior sides by curved lines, in order to represent the slope of the revetment of your double staircases. These curves must be drawn parallel to the original curves of your counterscap, which are arcs of a circle; and therefore, in describing them, the same points, that is to say the salient angles of your bastions and ravelins, must be used as centers.

160. Represent steps in the usual manner, and the double staircases of all the salient places of arms of the covered way will be complete. Those of the reentering places of arms shall next be drawn.

161. From each of the reentering angles of the counterscarp, set off 4 yards to the right and left in order to show the position of the foot of each of the interior sides of your proposed double staircases.

162. From the points, thus marked, as centers, with a radius of 10 yards, make intersections upon the original counterscarp lines of your plan. Let the new points thus found show the position of the tops of the interior sides of your proposed double staircases; and draw the said interior sides accordingly.

163. Make your staircases 2 yards broad; and draw the top, and bottom, and exterior side of each.

164. Draw right lines connecting the bottom of each pair of exterior sides, in order to show the front of the landing places of your double staircases.

165. Parallel to these lines draw a second set of lines, outwards, at a distance equal to the breadth of the slope of the counterscarp revetment, in order to show the extent of the slope of the revetment of your double staircases, in that part of each, which is immediately in front of the landing place.

166. Draw the slope of the revetment of each of the exterior sides of your double staircases; making the said slope, at bottom, equal to that of the counterscarp revetment, and from thence falling away to nothing at top.

This being done, the whole of the slopes of the revetment of each of your new double staircases will be complete, which by reason of the angles, could not be drawn in so simple a manner, as the corresponding slopes of your former staircases.

167. Draw perpendiculars, in the usual manner, to represent steps, and all the staircases of the covered way of your half octagon will be complete.

REMARK.

In afterwards penning your drawing, you may leave your landing places open in rear *(in the manner represented in the second figure of a double staircase, given in page* 139), in order to denote, that the said landing places are supposed to be on the same level with the bottom of the ditch.

But if, as is sometimes the case, the landing places of our staircases were supposed to be raised one step higher than the bottom of the ditch, then it would be necessary to represent the said step by a line drawn across the reverse of the landing place. In the staircases of the salient places of arms, this would be done by a

curved line; but in all the remaining staircases of communication by right lines.

When the ditches of a fortress are wet, the landing places of the staircases of communication, are always placed a little above the level of the surface of the water, so that men may be able to step out of a boat conveniently upon them. Consequently they are always at a considerable height above the bottom of the ditches. Sometimes, also, when the ditches of a fortress are dry, the landing places of the staircases in the reverse of works are not placed on or near the level of the bottom of the ditch, which we have hitherto supposed to be the case, but at the height of 6 or 7 feet above it. This is done, in order to prevent an enemy from penetrating easily into the various outworks, by means of the staircases at the gorge; and in this case the troops of the garrison themselves are obliged to use short ladders, for the purpose of ascending from the ditch to the level of the landing places, which they draw up after them into the interior of the work, as soon as the whole of any party of men, sent there on duty, have ascended.

In drawing the plan of a staircase of the last-mentioned description, the back of the landing place, and consequently the foot of each interior side of the staircases would not exactly agree, as in our former constructions, with the bottom of the interior slope of the gorge revetment of the work, in which it is supposed to be formed; but would require to be drawn a part of the way up the said slope.

For instance, if we suppose a double staircase to be constructed in the reverse of a work, the landing place of which is supposed to be raised to the height of 6 feet above the level of the ditch; whilst the gorge revetment of the work itself is 18 feet high above the same level; then the landing place being by supposition one third of the total height of the revetment, it will be evident that

the back of the landing place must, in a plan, be represented by a line drawn in front of and parallel to the bottom of the slope of the gorge revetment, exactly one third way up that space which represents the said slope. And the extremities of the back of the landing place, thus drawn, will also represent the position of the bottom of each interior side of the proposed double staircase.

But it is here to be observed, as on former occasions, that even under the above supposition, it would not be worth while, in any general plan of fortification, to mark the difference between the position of the back of the landing place of a staircase of this kind, and the bottom of the gorge revetment of the work in which it is supposed to be constructed. For example, in a landing place 6 feet high, the above difference would only be 1 foot, admitting that the gorge revetment had the usual slope of one sixth of its height. This difference, it may easily be conceived, would be by far too insignificant to notice, except in a detailed plan, drawn on a much larger scale than 50 yards to an inch. It is proper, however, as I must again repeat, that such minutiæ, in the art of plan drawing, although frequently omitted in practice, should be thoroughly understood.

Having made these remarks, we shall return to our construction.

168. Exactly in the middle of the center curtain of the body of the place of your half octagon, set off a space of 4 yards on the back of the terreplein, to show the breadth of a gateway; and in the middle of each of the remaining curtains of the body of the place, set off, in like manner, a space of 3 yards on the back of the terreplein, in order to show the breadth of posterns or sallyports; and from the various points, thus marked, draw perpendiculars, outwards, across your curtains, to represent the sides of the said gateway and sallyports.

These are supposed to be arched over, and therefore, in afterwards penning your drawing, they must be dotted.

That part of the entrance of each gateway, which is in rear of the back of the terreplein, still remains to be drawn. It is supposed to be left open at top, and is usually wider than the arched part of the gateway.

169. Draw the said entrances in all your curtains, making that of your center curtain 6 yards wide, but those of your remaining curtains 5 yards wide only. Represent the sides of them by small perpendiculars, drawn across the interior slope of the rampart; and let the center of each agree with the center of the corresponding gateway or sallyport, which you have already drawn, in the same curtain.

170. On each side of the above entrances, draw figures extending across the interior slope, to represent staircases of the rampart. Make these staircases about 3 yards wide; marking their sides by double lines to show the copings, and drawing also lines to represent steps in the usual manner. *(See Chapter VIII, page 136.)*

171. Draw a couple of lines perpendicularly across the curtain of each of your tenails, excepting that of the center front of your half octagon, at the distance of about 3 yards apart, in order to represent the sides of arched sallyports supposed to be placed exactly in the middle of each tenail; and recollect, in afterwards penning your drawing, that the said lines must be dotted.

172. In every curtain of your half octagon, excepting the center one, mark the front of each sallyport, upon that space, which represents the slope of the scarp revetment, by a small figure resembling a disproportioned elevation of a semicircular gateway. *(See the concluding part of Chapter XI.)*

Strictly speaking, a similar figure ought also to be drawn in the curtain of our center front, but we shall omit it for the sake of clearness, as it would make the back of the drawbridge, which is represented there, appear confused.

173. According to the strict principles of plan drawing, small figures, resembling disproportioned elevations of a semicircular

gateway, ought also to be marked in front and rear of each tenail of your half octagon, excepting the center one, upon those spaces which represent the slope of the scarp revetment, and the slope of the gorge revetment, of these works. You may mark them, if you think proper, observing however, that if the breadth of each of the said slopes, which in both is small, were laid off according to its just dimensions, it would scarcely be possible to introduce the small figures alluded to upon either of them, in a plan drawn on our present scale, without creating confusion.

The whole of the outline of your finished plan is now complete in all its details.

174. Pen your drawing, marking the revetments by red lines as usual, the remainder in black.

Observe also, that in addition to the scarp lines, crest of the glacis, and interior crest of each traverse, which, as it was before stated, must be penned by thick lines; the interior crest of the parapet of every work must also be made thick.

It is likewise usual in a general plan, like our present one, to pen with thick lines one cheek of every embrasure all round, choosing always, for this purpose, that cheek, which is nearest to the top or left side of your margin.

175. You may next shade your drawing with Indian ink, in which the rules generally observed are as follows.

First, those parts of a fortress, which are either horizontal or nearly so, such as the interior of works in rear of the ramparts, the terrepleins, banquettes, berms, ditches, and covered way, are always left blank or unshaded.

Secondly, all slopes are shaded; but in so doing, those slopes which approach nearest to a horizontal plane, that is to say whose base bears a greater proportion to their height than others, are

shaded lighter in proportion. For example, the glacis is usually shaded lighter than the exterior slope of the parapet.

Thirdly, in conformity with a rule mentioned in Vol. I. (*See page* 268) the light is always supposed to shine from the left extremity of the top of a drawing, in a diagonal direction, downwards; and consequently all the slopes of your fortress which face towards the top or left side of your margin, must be shaded light, whilst, those which face towards the bottom or right side of it, must be shaded dark.

Fourthly, in shading slopes, the Indian ink is applied stronger at one side than at the other, but the difference of shade must be gradual, the darker parts being softened away by degrees and the full effect required must not be attempted all at once, but by applying several successive shades one over the other.

In those sides of a work, which are supposed to face towards the light, and which are therefore shaded more lightly than the others, as was before observed, the various slopes must be shaded off, as it is called, from the bottom upwards; that is to say, the darkest part of the shade must be applied to that line, which represents the bottom or foot of the slope.

In those sides, on the contrary, which are not supposed to face towards the light, and which consequently must be made darker than the former, the various slopes must be shaded off from the top downwards.

Such are the rules, usually kept in view, in shading the finished plan of a fortress; but deviations from them may often be observed in well-executed plans, either for the sake of producing a better effect, or to render the plan clearer, which last point, next to accuracy of outline, is the principal merit in fortificational drawings.

176. You may next, if you think proper, colour your drawing, the rules for which are as follows.

Earthen slopes, such as the interior slope of the ramparts, the whole of the parapets, the traverses of the covered way, the glacis, and the slopes of the various banquettes, are usually washed over with a light tinge of green.

Dry ditches are washed over with a light tinge of brown, resembling the colour of sand. Wet ditches, when any are introduced, which is not the case in our present plan, must be washed over with a light tinge of blue to represent water.

Woodwork is usually coloured, so as to resemble the natural appearance of timber, before it is painted.

In the plan of a fortified city, when the streets are represented, the houses of the inhabitants are always stained red, this being the colour chosen to denote masonry, as has frequently before been mentioned. In military buildings, however, particularly such as are connected with the fortifications, a different practice is usually followed. In these, not their foundation or ground plan, but their roofs are often shown. For this purpose, after completing the outline of each building, which is thus to be represented, lines are drawn to mark the ridges and furrows of its roof, the sloping sides of which are afterwards shaded with Indian ink, according to the rules before stated ; and the whole is then washed over with a light tinge of blue to represent slating.

Strictly speaking, the same rules, which hold good in representing one kind of building, ought also to apply to all others, at least in the same plan. It is better however to make the above distinction, by means of which it can be seen at once, whether the buildings represented in the plan of a fortress are civil or military.

In penning streets or buildings, those sides, which face towards the top or left side of the drawing, are marked by thin lines, whilst

the others are made thick; the former to represent the light, the latter the shaded sides of the houses.

In architectural or mechanical drawings, representing buildings, carpenter's work, machinery, &c. the above rule is always followed in regard to the thickness of lines; so that, generally speaking, about one half of the lines introduced in them are penned thin, the remaining half being penned thick, according to the direction from whence the light is supposed to shine.

From the nature of the objects represented in such drawings, this contributes very much to render them clear and distinct. But in plans of fortification, in which a very great number of parallel lines are generally introduced, the same method, if followed, would create confusion; and therefore the principal lines of a fortress only are penned thick, in order to distinguish them from the others, without any regard whatever to the direction of the light.

It may also be observed, that, in geometrical drawings of buildings, machinery, &c. and more particularly in elevations, the shadows of the various parts are often represented, which when judiciously done, not only embellishes such drawings greatly, but contributes to their clearness. In plans of fortification, on the contrary, this is seldom or never attempted, because, in these, it would produce quite a different effect.

Part of the remarks, which have just been made, upon shading and colouring, &c. do not apply to our present plan, in which, for instance, no buildings either civil or military are represented. I thought it best, however, to introduce them here, in order to complete that part of my subject which relates to plan drawing; and which could not, in all cases, have been clearly explained, without occasionally mixing it with the rules for the various constructions:

although the work would certainly have been more methodical, if they could conveniently have been separated.*

177. After you have shaded, and if you judge proper, coloured your drawing in the manner above directed; write, as the title of it, in large letters, in any convenient place, the words PLAN OF A REGULAR OCTAGON FORTIFIED ACCORDING TO VAUBAN'S FIRST SYSTEM.

178. Insert a finished scale any where near the bottom of your margin: pen it; and write over it, *Scale of 50 yards to an inch.*

179. Finish your margin, in the usual manner.

REMARKS.

In your present construction, you must have observed, that after the simple outline of your half octagon was drawn, by far the greater part of the remaining lines, which were necessary for completing the finished plan of it, were found by merely referring to the profile or sections. But the method of transferring dimensions, from a section to a finished plan, is grounded upon such very simple principles, that when once thoroughly explained and illustrated by examples, in so ample a manner as has been done in our present plan, it could never be necessary to enter into any detailed explanation of these principles a second time.

In like manner, the rules for drawing the figures, resembling distorted or disproportioned sections and elevations, which generally

* Some of the above remarks on shading and colouring will also appear to be a repetition of what was said upon the same subjects in the first volume. This was done for the conveniency of those readers, who from their previous education may find it unnecessary to provide themselves with a copy of that volume. It may be observed, however, that the passages thus repeated do not occupy above a page at the utmost; and in other respects, the two volumes are independent of each other.

appear in finished plans of fortification, are in themselves exceedingly simple; so much so, that a person, who has once made himself master of them, and exemplified them by practice to a sufficient degree, can never be at a loss as to the proper method of applying the same rules, in any new cases which may occur.

Moreover, in drawing the ramps, barbets, staircases, &c. which must be introduced in a finished plan, a considerable part of the necessary dimensions may also be found by a simple reference to the profile or sections. The slope of a ramp, for instance, is usually made equal, in its widest part, to some adjoining slope, such as the interior slope of the rampart of the body of the place, ravelin, or other work, where it is supposed to be formed, and in like manner the slope of the revetment of a staircase of communication is made equal, in its widest part, to the slope of some adjoining revetment. The length of each ramp and staircase is also usually determined so as to bear a certain proportion to the height of the respective works, in which they are constructed, all of which heights are generally marked in the principal sections of the fortress.* Consequently, to those who are acquainted with these

* The proportion, which the length of every ramp, introduced in our present plan, bears to the height of the terreplein of the work, in which it is constructed, has already been explained. With respect to the various staircases of communication, the length of each has been made in such proportion to its height, as to admit of steps about 1 foot broad, and 6 inches high. For example, by referring to the second figure of your sections, you will find that the reverse of the tenail is 14 feet high above the level of the ditch; whilst the gorge of the ravelin is 22 feet high above the same level, and accordingly, in the former work, the staircases were made 6 yards long, in the latter 10 yards; the length of each staircase being greater than its height, by about one third, which proportion is exactly calculated for steps of the above-mentioned size The staircases of the covered way have been made equal in length to those of the ravelin, because the height of the counterscarp, in general, is nearly equal to that of the gorge revetment of the ravelins, as may also be seen by referring to your sections.

details, it is scarcely necessary to state any thing further respecting the construction of a ramp or staircase, than its length and breadth, with the position of the top or bottom of it; which particulars, it is evident, may be specified in a very few words.

As far as regards the simple outline, and the principal sections, which form the groundwork and most important part of any system of fortification, these may, in almost all cases, be amply explained in a very brief manner, as may be allowed by referring to Chapters V, and VI, and Plates 1, and 2.

Upon the whole it follows, that to persons, who have the previous knowledge above supposed; namely, who understand the method of transferring dimensions from a section, and who are acquainted with the rules for the construction of barbets, ramps, staircases, &c., and for properly representing the sloping extremities of works; the construction of the finished plan of any system of fortification may be explained, in a perfectly clear and intelligible, and yet in a concise, manner, without entering into one fourth part of the detailed explanations, which have been introduced in our present chapter.

The common authors on fortification always write in the brief manner, now alluded to. They give a sufficient number of explanatory plans and sections, it is true, but in laying down rules for the construction of them, they state the principal dimensions only, and they do not, in any case, enter into detailed explanations of the smaller parts of a fortress, nor do they ever attempt to illustrate the minutiæ of the Principles of Plan Drawing, as applied to the delineation of military works.

In consequence of this mode of treating their subject, although the writings of such authors may serve, either to add to the information or refresh the memory of those, who have previously studied

fortification under proper masters; they are by no means calculated to give any just or precise notions of the nature of a fortified place, to such readers as have no previous knowledge of the subject.

In the rules, which have hitherto been given for the various constructions, contained in this book, a very different system has been adopted; every point that was to be marked, every line that was to be drawn, and every arc that was to be described, having in all cases been distinctly and individually specified. This has necessarily swelled out our constructions, &c. to a very unusual length but if it had not been done, they would, like those of former writers, have remained almost entirely unintelligible to readers in general.

So much, however, has now been done for the sake of clearness, that the same minute attention to details will not be necessary in future. If you have paid due attention to the foregoing parts of this work, you must now be so far advanced, that you ought to be able to understand every thing that you may meet with in other books of Fortification,* and to comprehend with ease any plan, section, or other drawing, relative to that art, which may fall in your way. And for the same reason, if it appeared necessary, in continuation of my present subject, to explain any other system of fortification, different from that which has just been illustrated, I should think it quite sufficient, for your guidance, in drawing a

* At least all the practical rules, which, if founded upon just principles, form by far the most useful part of any work upon this subject. As for the geometrical theorems, algebraical formulæ, &c. which many writers on fortification have introduced for the purpose of demonstrating their rules; these cannot, of course, be understood without a much greater degree of mathematical knowledge, than the first volume of this work pretends to communicate.

finished plan of it, to state the principal dimensions only, in a concise manner, according to the practice commonly followed by former writers.

Having made these remarks, in explanation of the peculiar system, which has been adopted in this book, we shall now proceed to another part of our subject.

CHAP. XIV.

ANCIENT AND MODERN FORTIFICATION COMPARED.—THE NECESSITY OF FLANK DEFENCES EXPLAINED.—ADVANTAGES OF THE BASTIONARY SYSTEM OF FORTIFICATION.—REMARKS ON THE REDAN SYSTEM.—THAT THE GLACIS OF A FORTRESS OUGHT TO BE DEFENDED BY A PLUNGING, RATHER THAN BY A GRAZING FIRE.—OF THE COMMAND WHICH THE FLANKS OUGHT TO HAVE, OVER THE TENAIL, &c.

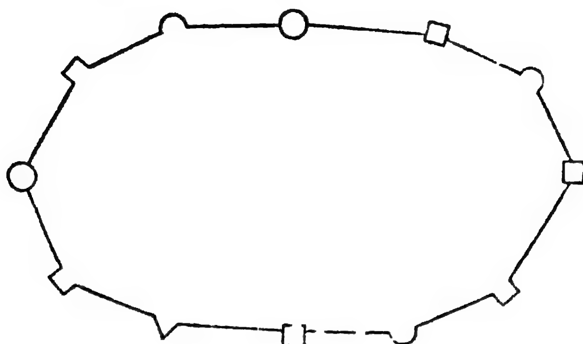
The finished plan of a regular octagon, which you have just drawn, together with the sections, that you before constructed according to scale, may serve to give you a complete notion of the nature of a modern fortress; particularly as all the minuter parts, which appeared to require a more ample explanation, have been fully treated of in detail.

I shall now explain the reasons, which have caused the above, or some similar system, to be adopted in modern times, as the best method of constructing a regular fortress.

This cannot be properly done, without going back to former periods, when very different methods of fortification were in use.

In ancient times, before the discovery of gunpowder, no bastions were ever used. The inclosing walls of a fortress, in those

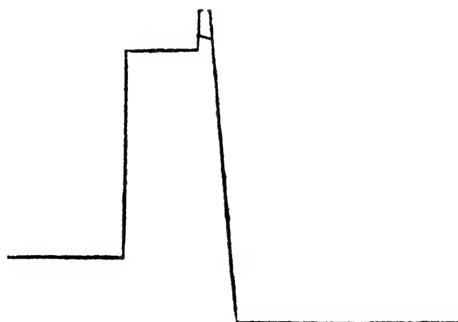
days, consisted of curtains and towers, which generally were either round or square. The sketch of the plan of AN ANCIENT FORTRESS was therefore as follows.



The ramparts were narrow, and almost always of masonry, built nearly perpendicular on both sides. THE TOWERS were usually higher than THE CURTAINS, and frequently, but not always, inclosed all round, so as to be equally strong towards the interior of the place, as towards the country. The parapets consisted of walls six or seven feet high, but seldom more than two feet thick, with small embrasures or holes open at top for the use of the archers or others defending the walls.

The upper part of the wall or rampart, including the parapet, constituted what was called THE BATTLEMENTS.

The section of the curtain of an ancient fortress may be represented by the annexed figure; in which the wall or rampart, the parapet, and the embrasure, are distinctly shown



In addition to the small embrasures above described, there were generally holes for the same use, cut somewhere through the lower part of the walls, and particularly in those of the towers. These holes were usually about two or three feet high, and seldom much more than six inches wide on one side, but considerably wider on the other. Their splay, which resembled that of an embrasure, was intended for a similar purpose, in order to enable the archers to command a sufficient space of ground to the right and left. They were not cut in a horizontal direction, but usually so as to slope a little downwards.

The holes, thus pierced through the body of a wall for the use of the defenders, were called CRENELLES OR LOOPHOLES.

Loopholes, pierced through a thick mass of masonry, were of course limited in their range, and there must have been points outside, particularly near the foot of the walls, where the assailants could not be seen or annoyed from any of them. This disadvantage, however, did not apply to the defences arising from the battlements. It will readily be understood that archers posted there, behind the thin parapets above described, could easily discover every thing that was passing in the ditch, and even at the very bottom of the walls, immediately below them, and that they could take aim through their embrasures at any enemy in that position, who might be preparing to scale or otherwise assault the fortress, in the same manner, that by looking out over the sill of the upper window of a common dwelling house, you may see and fire at any persons in the street below, who may be attempting to break open your door.

There was another contrivance, used in ancient times, for the convenience of shooting perpendicularly downwards, and for throwing heavy stones, combustibles, &c. upon an enemy standing at the bottom of the walls with a view to assault them.

This consisted in forming vertical loopholes, through which the

defenders might annoy the assailants; and as the object of these was to shoot downwards only, the soldiers who were posted there, were protected by a parapet in front and on each flank.

This contrivance, which shall now be described, was called A MACHICOOLY.

At the distance of two feet and a half apart from each other, or thereabouts, long stones called CORBELS were built into the wall, the ends of which projected about three feet, or as much as might be judged necessary, beyond the outside of it.

A stone floor, either arched or consisting of long flat stones, was laid over these corbels and supported by them, in which state they exactly resembled a common balcony.

In the floor of this balcony, the vertical loopholes for shooting downwards were cut, and the sides and front of it were built up with a thin parapet six or seven feet high.

It will easily be understood, that a man standing behind this covered balcony or machicooly could not be seen by the enemy's troops from without; and yet that he would have it in his power to annoy them by very effectual means of destruction, as soon as they approached the foot of the walls.

The machicooly was placed near the summit of the walls, and more especially over gateways, to prevent an enemy from forcing them.

From the common battlements of an ancient fortress, above described, it was also possible for men to shoot perpendicularly downwards, as was before observed; but then, in so doing, it was necessary for them to lean over the sills of the small embrasures, in which they could not avoid exposing a great part of their body.

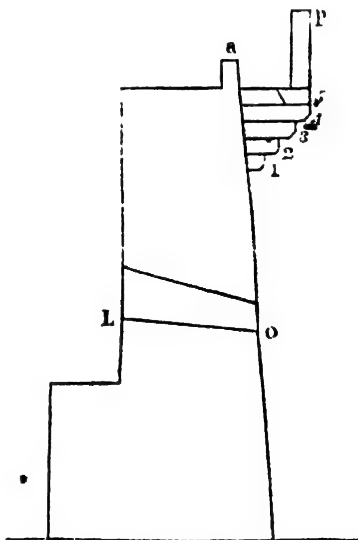
In the machicooly, on the contrary, a man is scarcely exposed at all, for an enemy has no means of annoying him, except by firing

perpendicularly upwards, through a small hole, which it is almost impossible to do with any effect.

In common balconies, there is only one stone used for each corbel; but in the machicoolies, which I have described, it was usual to form the corbels of several courses of stones, which added greatly to their strength.

For instance, in constructing a machicooly, which was intended to project three feet beyond the general line of the wall, four courses of stone might be used for each corbel: the first or lowest course to project nine inches; the second course eighteen inches; the third course twenty-seven inches: the fourth course to complete the thirty-six inches, or the three feet, required.

In the annexed section of an ancient wall, crowned by a machicooly, 1, 2, 3, and 4, represent four courses of masonry, projecting from the body of the wall in such a manner as to form the corbel. These are seen in elevation, the section being supposed to be taken through the intermediate space between two corbels.



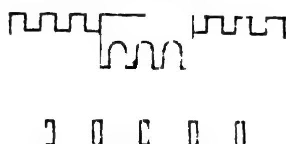
5, represents the course of covering stones, or arch, forming the floor of the machicooly, through which the vertical loophole is cut.

P, is the parapet which covers the machicooly in front.

And a, is a small interior parapet to prevent accidents, which might arise from men stepping into the vertical loopholes.

L o, is a crennel or common loophole, pierced through the body of the wall, as before described.

By way of further illustration, the exterior elevation of an ancient tower is added. In the center of the battlements a machicooly with four corbels is represented, on each side of which is a common thin parapet with small embrasures for archers. Halfway down is a row of crennels or loopholes.



After fire arms were invented, the ancient ramparts, which answered very well for archers and even for musquetry, were found much too narrow to admit of great guns being mounted and manœuvred upon them.

For this reason, it became necessary greatly to increase the width of the ramparts, which was done, not by adding more masonry, but with earth and rubbish, for the sake of economy. Hence arose the modern terreplein or body of the rampart, with its interior slope.

It was also found, that the thin parapets of antiquity could make no defence whatever against cannon shot. Therefore their thickness was increased to eight or ten feet of solid masonry.

Parapets of this description resisted cannon shot for a certain time, but after continued firing, they were ruined by degrees, and the fragments of stone and bricks, knocked off in all directions by the effect of the enemy's batteries, were found exceedingly trouble-

some, and even destructive to the defenders, often doing more mischief than the cannon balls themselves.

Parapets of masonry were therefore entirely abandoned, and the thick earthen parapets of modern fortification adopted in their stead.

These offer by far the best protection against cannon shot: for in a mound of earth, the ball will either bury itself without doing any mischief, or if it glances off after grazing, no dangerous splinters are produced. Earthen parapets are likewise not only the most difficult to ruin, but the easiest to repair.

It is further to be observed, that in ancient times, height was considered a principal criterion of the strength of a fortress; so that it is common to meet with ancient walls or towers, from fifty to seventy or eighty feet high; and some may be seen considerably higher, even than the last-named dimension.

After cannon were invented, such high walls as these were found to be very prejudicial. For the besiegers might establish their breaching batteries at long ranges, that is to say, at about a thousand yards from the fortress. The fire of cannon, although sufficiently powerful and destructive against any object, which it may happen to strike, is very uncertain at that distance. Therefore the besieger's batteries being low and small objects, and formed with earthen parapets, could receive little or no injury from the fire of the place: whereas the high extensive walls of the fortress presented so large a mark, that they could not fail to be struck somewhere, by every shot that was fired against them. Consequently, after a few days firing, the fortress might be laid open and exposed to a general assault, with scarcely any loss whatever being previously sustained by the besiegers.

For this reason, the high naked walls of antiquity were abandoned, and much deeper ditches than were usual in ancient times

were introduced; by means of which the walls of a modern fortress are, as it were, in a great measure buried below the surface of the ground; and to secure them still further against the effect of distant cannon shot, counterscarps and glacis, contrivances unknown to the ancients, have been raised in order to screen the upper part of them.*

By these means, the revetments of a well-constructed modern fortress, although still of such a respectable height, as to secure them against the risk of being easily taken by escalade, are so completely covered; that no part of the masonry can even be seen from the country.

Consequently it is impossible for an enemy to effect a practicable breach, in a place properly fortified according to the modern system, by distant batteries. He must necessarily establish his breaching batteries, and bring up his guns, close to the crest of the glacis, that is to say almost to the very brink of the ditch, before they can see any part of the revetments. This involves him in a number of long and tedious operations, not to be effected without great labour and loss; for in so doing, his troops are exposed to a close fire both of cannon and musquetry, and may be annoyed by mines and other offensive means, which are not to be feared whilst they continue at a distance.

It is to be observed, that as far as regards the object of covering the revetments only, a simple counterscarp and glacis would answer equally well, or indeed better, without any covered way.

* As there were ditches in ancient fortresses, the counterscarp, if taken in one sense merely as the exterior side of the ditch, cannot, strictly speaking, be said to have been unknown. It was unknown, however, as a cover to the walls, which is its principal use in modern fortification.

The latter work has been introduced in modern fortification, principally for the conveniency of making sorties. The troops intended for that purpose may there be assembled to advantage, in any number that can be required. From thence they may, by means of the ramps, and by short ladders sometimes used for clearing the palisades, speedily form upon the glacis, preparatory to an attack upon the besiegers; and after the object of their sortie is accomplished, the covered way affords them a safe retreat, as also a place of support, from whence they may in retiring be protected by reserves of infantry.

If, on the contrary, a fortress were constructed without any covered way, there would be no means of retreat after a sortie, except by the bridges and gates, where only a small number of men can enter at once; so that the others might be obliged to wait for a considerable time, upon the glacis, completely exposed to the enemy's fire, without any parapet or cover to protect them. Consequently, in a place constructed in such a defective manner, the troops employed in a sortie, if vigorously pressed, must be thrown into the utmost disorder; so much so, that a part of them might be driven headlong into the ditch, whilst the remainder being crowded together in a state of helpless confusion on the bridges and gateways; a daring enemy might even have an opportunity of taking the place, by entering pell-mell with the fugitives.

Independent of the important advantages, which it thus affords to the defence of a fortress, by facilitating the operations of a sortie, the covered way is also of use, as a post for musquetry, from whence the enemy may be checked in his attempts to establish himself, near or upon the glacis of the place besieged. But more will be said upon this subject hereafter. In the mean time, we shall return to our investigation into the difference between ancient and modern fortification.

The changes, which took place in the profile of fortresses, sub-

sequently to the invention of gunpowder, have already been accounted for. The difference in the outline or plan remains to be explained.

It was before stated, that from the thinness of the parapets of an ancient fortress, the defenders might, by leaning over the sills of their embrasures, see every thing that was passing at the bottom of the walls immediately below them, and might take aim at any enemy in that position.

When the thickness of the parapet was increased, this became no longer practicable, for it must be evident, that a man standing behind a parapet from ten to eighteen feet thick, cannot possibly see any thing that is passing at the foot of the revetment immediately below him, nor can he possibly fire at an enemy in that position.

In order to illustrate this remark by a figure, draw the section of the rampart of a regular fortress.

This being done, produce the superior slope of the parapet, outwards, by a dotted line, until it meets the level of the ditch.

Mark this point by the letter c. Mark the interior crest of the parapet by the letter a; the exterior crest of it by the letter b; the foot of the revetment by the letter d; and the extremity of the ditch by the letter e.

From the crest of the parapet, a, drop a perpendicular, a f, meeting the level of the ditch, produced backwards, in the point f; and dot these new lines.



Then the point, c, represents the nearest point of the bottom of

the ditch, which it is possible for a man, standing on the banquette and firing over the parapet, to strike with a musquet ball; and it will be evident, on inspecting the figure, that almost the whole of the space, b c d, is secure against musquet shot, and that particularly nearly the foot of the scarp, d, there is no danger whatever to be incurred from that weapon.

Consequently, after the necessary alteration of the profile, occasioned by the use of gunpowder, was introduced, if the outline or plan of the modern fortress had not been altered at the same time, it would have had very little strength.

The enemy, after getting into the ditch, and advancing to the foot of the walls, would have been perfectly secure from the fire of the besiegers. He might therefore have planted his ladders in safety, and scaled the work with very little risk.

But although, from the banquette of the modern fortress, you cannot fire against an enemy in the ditch either near you or immediately below you, yet the superior slope or dip of the parapet permits you to fire upon an enemy placed below you on the level of the ditch, at a certain distance from you. For instance, in your present figure, you may fire upon an enemy, in any part of the ditch beyond the point, c, as far as e, or further, if the ditch were of greater extent.

To reduce the thing to calculation, if we suppose the perpendicular height, a f, of the crest of the parapet, a, above the level of the ditch, to be thirty-six feet, and that the parapet has a dip of one sixth: then six times thirty-six feet, or in other words seventy-two yards, set off horizontally, from the point f, outwards, upon the bottom of the ditch, will determine the point c; and if we suppose f d, to be about ten yards, then by deducting this from seventy-two

yards, a difference of sixty-two yards will remain for the length of d c: that is to say, a soldier standing behind the parapet, may, with a musquet ball, strike a point, c, at the bottom of the ditch, not less than sixty-two yards distant from the foot, d, of the revetment immediately below him. But as a man's height raises him some feet above the level of the ditch, an enemy would not be quite secure from musquet shot, until he got ten or twelve yards nearer than the point c, that is to say, until he approached to within about fifty yards of the foot of the revetment.

At a smaller distance than the above, you will neither be able to see nor to fire at any object in the ditch, unless you were to quit the banquette, and mount upon the top of your parapet; in which case you would be as much exposed to musquetry yourself, in defending your fortress, as an enemy would be in assaulting it.

By increasing the dip of the parapet, it is true, that from a parapet thirty-six feet high you might be able to fire at a person in the ditch below, at a smaller distance than fifty yards; but this advantage carries a great inconvenience along with it, which counterbalances it. For the more the dip is increased, the weaker will the crest of the parapet become.

To explain this remark: if we suppose the dip of our parapet to be increased from one sixth to one third, the height of it remaining the same: then the distance, f c, will be three times thirty-six feet or thirty-six yards, instead of seventy-two; and deducting ten yards for f d, as before, twenty-six yards only will remain for the length of d c: that is to say, a man from the parapet may, with a musquet ball, strike any point, c, at the bottom of the ditch, not less than twenty-six yards distant from the foot of the revetments; but for a reason before stated, an enemy would not be quite safe in the ditch, until he got to a less distance than the above; for

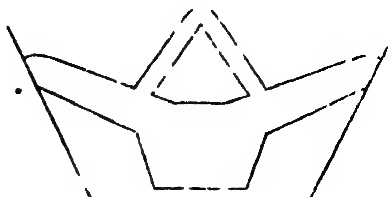
instance, to within about twenty yards from the foot of the revetments.

Thus, by increasing the dip of our supposed parapet from one sixth to one third, it appears that it will have a much greater command of fire over the ditch below, which certainly would be of essential advantage; but unfortunately the upper part of a parapet would, by such a construction, become too thin to protect the defenders against an enemy's artillery: and it has therefore, as a general rule, been judged advisable, in parapets exposed to cannon shot, not to allow a dip of much more than one sixth of their thickness.*

Since then, generally speaking, no part of the foot of the revetments or of the ditches of a modern fortress can possibly be defended by its own immediate parapet, but requires to be protected by the fire of some other part of the parapets not less, on an average, than fifty yards distant from it: hence arose the necessity of disposing the outline of the body of the place in such a manner, that every part of the foot of the revetments and every part of the ditches in general, could be seen and protected by the fire of some more distant part of the ramparts. And it was found, that this advantage could not be gained in any way, but by adopting the form of bastions and curtains, for the main inclosure of the fortress.

* The dip of the parapet, however small, always weakens the crest of it in some degree. For this reason, the French writers on fortification in general allow very little. Cormontaigne, for instance, gives his parapet a dip of one ninth only, although it is supposed to be 42 feet 10 inches high, above the level of the main ditch. Consequently it is impossible, from thence, to see into any point of the ditch, nearer than 128 yards, measured horizontally from the crest of the parapet: so that an enemy, in the ditch, would be perfectly safe from direct musquet shot, any where within about one-hundred yards from the foot of the revetments.

In order to explain this remark, draw a front of fortification with a ravelin; and observe the figure attentively.



If an enemy should get into the main ditch before the curtain, and close to the foot of the revetment of it; from what has been said before, it will be evident that he cannot possibly be annoyed by the fire of the curtain itself: but he would be completely exposed to that of the adjoining flanks.

If he attempted to scale either of the faces of the two demibastions, he would also be exposed to the fire of the opposite flanks.

In like manner, the faces of the demibastions, although incapable of defending their own revetments, can bear upon a great part of the ditches of the ravelin, and are consequently able to contribute to the defence of that work, in case an enemy should attempt to assault it.

In short, in modern fortification, no work or outwork can effectually defend itself by its own fire, but must necessarily be defended by the fire of some more distant or retired part of the same system of works; and generally speaking, any work or outwork, which is defended by another, is said to be flanked by it; because in almost all cases, in regular fortification, the defending work will be found to protect the other, against an enemy who may be preparing to assault it, not by a direct fire, but by a fire in flank, or by what is termed an enfilading fire, as was before explained.

For instance, in a regular fortress, THE FACES OF A BASTION

ARE SAID TO BE FLANKED by the flanks of the adjoining bastions: and in like manner, A RAVELIN IS SAID TO BE FLANKED by the faces of the bastions in rear of it.

It may here be observed, that an enfilading fire is much more destructive to a line of troops than a direct fire.

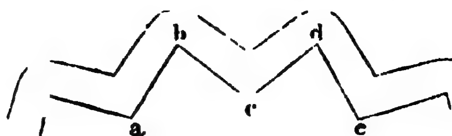
On account of the reasons, which were before stated, it has been laid down as a rule in modern fortification, that every part of a fortress should be flanked by some other part of it; and it has been shown that this advantage is obtained by laying out the inclosing rampart in the form of bastions and curtains; or in other words, by adopting what has been called THE BASTIONARY SYSTEM OF FORTIFICATION for the body of the place.

I shall next explain, why no simpler figure or system than the above will answer the object in view.

If the outline of a fortress were traced in the form of a continued curve, such as a circle or an ellipse; or if its sides were laid out like those of a geometrical polygon, without any reentering angles; it would be quite impossible for a person, standing behind any part of the parapets, to see into any parts of the main ditch whatever: and consequently the fortress would not be flanked at all. This will be sufficiently evident, without any further illustration by means of figures or otherwise: and therefore there is no instance of fortresses ever having been so constructed.

If, on the contrary, the main inclosure of the fortress were laid out without any regular bastions, but in the form of a star, that is to say, with salient and reentering angles alternately, then every face might be able to flank or defend a part of the adjoining face, but not the whole of it.

Draw a figure to represent part of a fortress supposed to be constructed in the last-mentioned manner: and mark some of the angular points of the body of the place by the letters, a, b, c, d, and e.



Before we proceed further, it is proper to remark, that when a work is laid out in this manner, any two faces of it, which form a salient angle, constitute what is called A REDAN. For instance, a b c, in our present figure, is a redan: c d e, is also a redan, &c.

And when a fortress is constructed in the above form, it is said to be fortified according to THE REDAN SYSTEM OF FORTIFICATION, by way of contradistinction from the bastionary system, which has already been very fully explained.

In the redan system, each front of fortification consists of two faces only, forming a reentering angle, such as, b c d, for instance, and therefore exactly resembles a simple tenail; for which reason this system has, by some authors, been also styled THE TENAIL SYSTEM OF FORTIFICATION.

The defects of the redan or tenail system shall now be stated.

Let the parapets of the body of the place of our present figure be supposed to be thirty-six feet high, with a dip of one sixth; then agreeably to our former calculation, they will not be able to defend, by musquet shot, any part of the ditch, which is less than fifty yards distant from the foot of the revetments below them.

Therefore, if we suppose the two faces, b c, and c d, of our figure, to be each only thirty yards long, then it will be evident, that they are too near to each other for the purposes of mutual defence; and that neither of them will be able to flank or defend the other properly. Consequently the whole of the reentering angle formed by these two faces is undefended or unflanked.

An angle of this kind, in fortification, which is not properly flanked, is called A DEAD ANGLE.

And in like manner, any line or face, which is unflanked, is said to be A DEAD LINE. Consequently, under the present supposition, the whole of the faces, b c and c d, are dead lines, and the angle, b c d, as before mentioned, is a dead angle.

But if we suppose the faces, b c and c d, to be each a hundred yards long, then about one half of each face would be more than fifty yards distant from the other face which was to defend it. Consequently about one half of each of the two faces would be properly flanked, but the remaining parts of them, towards the reentering point, would form a dead angle.

Owing to this imperfection, the redan system of fortification has never been adopted in practice, for the construction of any fortress of importance, although some authors have written strongly in favour of it.* It is not uncommon, however, to see a few redans occasionally used in the inclosure of a great fortress; but this has seldom or never been done to any extent in modern times, except in cases where the irregularity of the ground or other circumstances have been unfavourable for the construction of bastions.†

I shall here observe, that in the redan system of fortification, the reentering angles are sometimes called the flanking angles. Thus

* Particularly Montalembert, who at the same time that he gives a decided preference to the redan system above any other, recommends, that all the reentering angles of a fortress so constructed should be right angles; and therefore he adopts the term "Perpendicular Fortification" as the title of his book.

† As for instance, in the works constructed on the Western Heights at Dover.

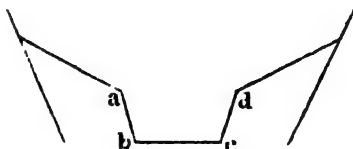
for instance the angle, b c d, is A FLANKING ANGLE, because those parts of the two faces forming it, which are nearest to the angular point, flank the salients on each side of them.

For the same reason, the salient angles, in the redan system, which derive their defence from the others, are also styled the flanked angles. Thus, for instance, the angle, a b c, is A FLANKED ANGLE.

In a fortress built according to the redan system, it being quite impossible, as has been shown, for a very considerable part of the ditches and revetments to derive any defence whatever, either by cannon or musquetry, from the parapets of the body of the place; the advocates of that system, in order to obtain the necessary means of firing into the dead angles of their work, have therefore been obliged to have recourse to casemates and galleries, the nature of which shall hereafter be described. In the mean time we shall proceed with our former subject.

It will now be clearly understood, that none but the bastionary system of fortification has the advantage of affording a complete flanking fire for every part of the main ditch and revetments of the body of the place. It only remains to observe, that if a fortress, traced according to this system, is constructed on too small a scale, the above important advantage, which ought to arise from the regularity of the plan, may no longer be obtained.

For example; draw a regular front of fortification, and mark the two flanks by the letters, a b, and c d.



Then if we suppose the fortress to be constructed on such a scale, that the curtain, b c, is a hundred yards long, one half of it may be flanked from a b, and the other half from c d.

But if the fortress were supposed to be constructed on so small a scale, that the length of the curtain, b c, were less than fifty yards: then the two flanks, a b, and c d, would be too near to each other to defend it properly, in any part whatever.

From this consideration, the necessity of giving a certain length to the curtains of a regular fortress will be evident. As far as regards the bastions, it might however, be supposed, that towers like those of antiquity, if constructed in the bastionary form, instead of being made square or round, and if placed at a sufficient distance from each other, would sufficiently answer the purposes of defence; as they would offer no dead angles and no undefended lines or faces; and on inspecting a simple outline, this would appear to be the case. But when the matter comes to be more fully considered, it will be found, that even in a tower of very large dimensions, if you construct earthen parapets of a proper thickness to resist cannon shot, there will be little or no room left for mounting guns. Consequently the flank defences, to be derived from any kind of tower, are too trifling to be worthy of notice: and for this reason, not only the form, but also the magnitude of the bastions used, became of importance, in modern fortification.

Upon the whole, it may now be understood, that the perfection of the bastionary system of fortification does not merely consist in its figure, or in the proportion which its several parts bear to each other. The actual dimensions of these parts, that is of the faces, flanks, and curtains, are also of importance. They may admit of considerable variation, but at the same time there are certain limits, beyond which they cannot be increased or diminished, without prejudice to the strength of the fortress.

It will also be understood, that when a small work is to be built on any limited spot of ground, it will be best to construct it

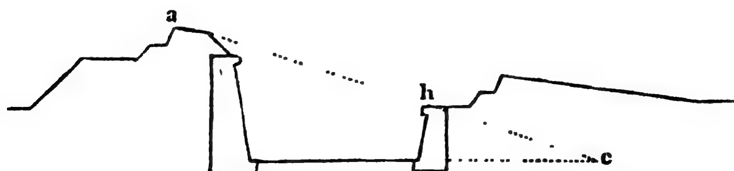
of any simple figure, suited to the nature of the ground; without attempting to give it regular flanks, which, on a very small scale, will be of little or no use.

Small inclosed works, constructed without any regular flanks, are called redouts, the nature of which will afterwards be more particularly explained.

The covered way of a regular fortress is much more elevated than the level of the bottom of the ditch: and therefore the fire of musquetry from the parapets is able to see into any part of the covered way, immediately in front of them, even at a much less distance than fifty yards, which I before gave as the least average distance, at which the ditches can be defended.

Draw the complete section of a fortified place, showing the ramparts, ditch, covered way, and glacis: and let the dip of the parapet be such, that the superior slope when produced shall meet the reverse of the covered way, in the point h.

Mark the crest of the parapet as before by the letter a: dot the line, a h, which represents the path of a musquet shot supposed to be fired from the parapet; and produce this dotted line, until it meets the level of the ditch, also produced outwards, at the point c.



On inspecting this new figure, it will be evident, that direct musquet shot from the ramparts may defend the covered way to great advantage, at or beyond any point, h, at a much less distance than c, which is supposed to be at least fifty or sixty yards from the foot

of the revetment; and nearer than which, it is not possible to strike any object at the bottom of the ditch.

From the same figure, it will also be evident, that although, in the redan system of fortification, a great part of the ditches and revetments cannot be defended by a fire of musquetry from the ramparts; yet the whole of the covered way and glacis of a place so fortified may be effectually protected thereby.

In determining the profiles of a regular fortress, it has always been considered desirable to bring the whole of the covered way under the fire of the parapet immediately behind it, in the manner shown in our present figure, which we shall suppose to represent a section taken through the face of a bastion.* It will be observed that no part of the ditch whatever can, in this figure, be seen from the ramparts by a direct fire of musquetry; and the same remark applies to fortresses in general: for, as has been so often stated, it would require a ditch to be more than fifty yards wide, before any part of it could be so defended; but this is a much greater width than is ever given to the main ditch, even of a very large fortress.

Being deprived of the advantage of a direct fire from the ramparts immediately in rear of them, the ditches of a fortress must therefore depend entirely upon the flanking fire, which is produced by planning the various works according to a judicious outline, such as that of the bastionary system. But the covered way and

* The French writers, in general, are satisfied if they can bring the foot of the banquette of the covered way under the direct fire of the parapets. This is the case in Cormontaigne's profile, mentioned in a former note, in which no part of the interior of the covered way behind that point is seen into; but on account of a man's height, which, of course, must always be taken into consideration; an enemy would not be secure against direct musquet shot in any part of it.

glacis of a fortress have the advantage of being defended both by a direct and flanking fire, or in other words by a cross fire.

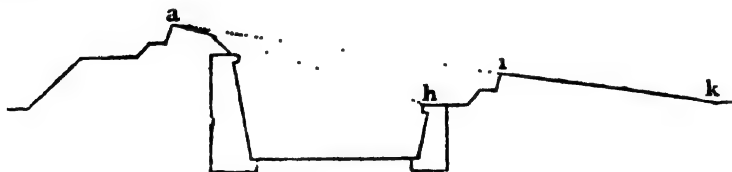
A CROSS FIRE of artillery is, in all cases, much more harassing and formidable to troops than a direct fire, particularly if a part of your guns can be so disposed as to enfilade an enemy's line, whilst the remainder of them bears upon him in front. In that case, a cross fire will be more destructive than a simple enfilading fire.

For this reason, not only in the bastionary but also in the redan system, it has always been considered an advantage, that the outline of each is so constructed, that a cross fire is obtained from the ramparts, in every front.

Having sufficiently treated of the ditches and covered way, the defence of the glacis now only remains to be considered.

The glacis of a fortress may be defended from the parapets, either by a grazing or by a plunging fire.

To explain these terms, draw a dotted line, a i, from the crest of the parapet to the crest of the glacis, in your present figure, and alter the slope of your glacis, i k, if necessary, until it agrees with the above line produced.



This being done, a i, and i k, will form one continued right line, so that a musquet ball from the parapet, fired with due accuracy at any point of the glacis, k, for instance, must graze or shave the surface of the slope nearly. A shot so fired is therefore called a grazing shot; and when the parapet and glacis of any work are

thus disposed in regard to each other, the former is said to command or protect the latter by A GRAZING FIRE.

In a grazing fire the shot flies nearly parallel to the surface of any work or piece of ground, against which it is directed. The term plunging shot, on the contrary, implies that it strikes the surface at an angle.

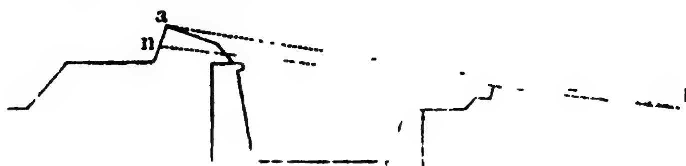
Thus the line, a i k, may represent the path of a grazing shot fired against the glacis, whilst the line, a h, will represent the path of a plunging shot fired into the covered way.

When the slope of the glacis is directed upon the crest of the parapet, in the manner represented in our present figure, a grazing fire of musquetry only, but not of artillery, is obtained from the ramparts.

It was before explained, that cannon mounted on the terrepleins of a fortress usually fire through embrasures cut for the purpose; but the muzzle of a gun so placed always stands nearly four feet lower than the crest of the parapet. For this reason, when a grazing fire of artillery is desired for the defence of the glacis, the slope of it should be directed, not exactly upon the crest of the parapet, but so as to fall four or five feet lower.

Rub out the dotted lines in your section. Mark a point, n, rather more than half way down the interior slope of your parapet, to represent the height of the muzzle of a loaded cannon, ready to fire through an embrasure, and pointed towards the glacis. From this point, draw a dotted line to the crest of the glacis; and alter the slope of the glacis so as to agree with the above line produced.

From the crest of the parapet, a, draw also a dotted line, a k, to the foot of the glacis.



In the present state of your figure, the right line, n k, represents the path of a cannon ball, which if fired from the ramparts, with due accuracy, at any point on the glacis, such as k, would graze the surface nearly.

And the line, a k, represents the path of a musquet ball fired from the parapet at the same point, k, which in consequence of the alteration of the slope of the glacis, is no longer as before a grazing shot, but plunges in a small degree.*

Some authors on fortification have recommended strongly, that the profile of fortresses should always be proportioned in the manner represented in our present figure, or nearly so, in order to obtain a grazing fire of artillery from the ramparts upon the glacis, and a great number of fortresses have actually been built in conformity with this system.

The above maxim, however, does not seem to have been adopted with due consideration. On the contrary, it appears to me radically bad in several respects. In the first place, it renders the covered way, as a work of defence, of little or no use to the besieged. A soldier standing on the banquette of the covered way,

* It was mentioned in a former note, that the path of a shot, properly speaking, is a curve, not a right line, as supposed in the text. But in the figures and remarks, intended to illustrate the simple principles, laid down in this chapter, it was not thought worth while to notice the difference, which at short ranges is very trifling.

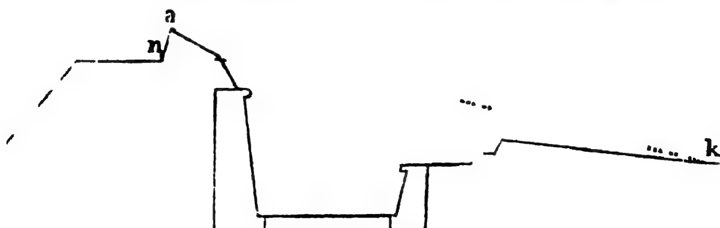
to fire against an enemy, has his head and shoulders elevated above the crest of the glacis. Consequently the grazing shot from the ramparts will every moment be liable to destroy your own troops, who line the covered way; so that these troops, instead of being in a state of activity, cooperating with the interior defences of the fortress, would be forced to sit down, in order to secure themselves against the fire of their own fellow soldiers.

This reason alone, independent of others, points out that a grazing fire ought to be rejected; and that the ramparts of a fortress should command the glacis in front of them by A PLUNGING FIRE, not only of musquetry, but also of artillery.

Alter the rampart of your figure, by raising it considerably higher than it is at present; leaving the covered way and glacis as they are.

Mark a point, n, in your new figure, rather more than half way down the interior slope, to represent, as before, the height of the muzzle of a cannon supposed to be ready to fire through an embrasure.

And draw the dotted lines, a k, from the crest of the parapet, and, n k, from the last marked point, to the foot of the glacis.



Then the line, n k, will represent the path of a cannon ball fired from the ramparts against the foot of the glacis, which, as you may observe by the figure, will pass a good deal higher than the crest of the glacis; so that troops might man the covered way without being injured by it.

The line, a k, will represent the path of a musquet ball fired also from the ramparts against the same point, which in its flight passes still higher than the former, and consequently at a greater distance from the troops in the covered way.

It will now be understood, that when the parapets of a fortress command the glacis by a sufficiently plunging fire, in the manner represented in our present figure, the men in the covered way are not exposed to any danger from those who man the works in rear of them. A combined fire of artillery and musquetry from the ramparts, and of musquetry from the covered way, may therefore, without inconvenience, be kept up at the same time, against an enemy posted at the foot of the glacis.

I shall mention another reason, which renders a grazing fire improper for the defence of a fortress. In a siege an enemy is always obliged to dig trenches and throw up parapets, in order to cover his troops against the fire of the place attacked; and these operations, which are commenced at a distance, must be continued even upon the glacis. A very moderate labour, however, renders a trench secure against grazing shot, which merely sweep the surface of the ground that is to be excavated. But when the works of a fortress are so commanding, that the shot fired from them plunge downwards at an angle, it necessarily requires the besiegers to form much deeper trenches and higher parapets, for their own protection. This adds considerably to the difficulties of the siege, by causing them to incur a greater loss of lives, labour, and time, than would otherwise be necessary.

Having stated the objections to a grazing fire, it is to be observed, that against troops drawn up in the open field, and not protected by trenches of any kind, like a besieging army, it is sufficiently efficacious; and therefore, although not to be recom-

mended in permanent works, it may be used to great advantage in field fortification.

I shall conclude by adding some further remarks on the flank defences of the bastionary system, which could not conveniently have been introduced before, without confusing the subject.

Whilst it was explained, in a former part of this chapter, that the fire of the flanks can see into and defend every part of the main ditch of a regular front of fortification, it was stated that the faces of the demibastions, which are directed so as to flank the ravelin, can only bear upon a great part, but not the whole, of the ditch of that work. The reason is, that the inward extremity of each face of the ravelin is less than fifty yards distant, from the foot of the revetment of that part of the bastion, which ought to defend it: but at less than the above distance, it has been shown, that no part of the ramparts can fire upon troops in the ditch. To bring the matter to a rough calculation, it may be assumed, that even in the largest fortress, the inward extremity of the ravelin is seldom more than forty yards distant from the revetments of the body of the place; which distance, being deducted from fifty, leaves a difference of ten yards. This therefore, in fortresses in general, may be considered as the least average extent that can be allowed for that part of each face of the ravelin, which becomes a dead line, and of which the ditch is not seen into by the fire of the body of the place.*

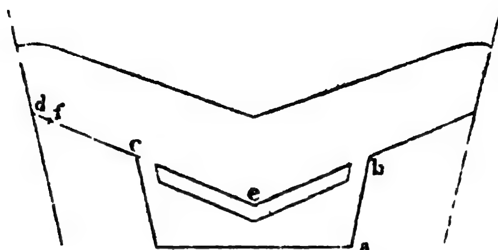
It is next to be observed, that the whole of the main ditch, even in the bastionary system of fortification, is not completely flanked,

* In the above calculation, I have supposed the ditches of the ravelins to be on the same level with the main ditch, which is usually the case. If they were on different levels, it would produce a difference in the extent of the dead part of the face of the ravelin, which would become more or less than ten yards accordingly.

excepting in such fronts as have no tenail. That work necessarily prevents the fire of the flanks from seeing into the central part of the main ditch, which is immediately in front of it, and in rear of the ravelin. An enemy, who had penetrated into the main ditch, might therefore make his preparations for assaulting the tenail, without being exposed to the fire of any part of the ramparts whatever. But this has been considered a very trifling disadvantage, because after taking possession of the tenail, he would find it exceedingly difficult to maintain himself there, under the fire of the body of the place; and he would next have to attack the curtain, the revetments of which, together with the narrow ditch in front of it, are completely flanked. In short, by so acting, he would direct his attack upon the strongest part of the main inclosure; and involve himself in much greater difficulties than by attempting the bastions. To explain this remark at large would require a full consideration of the art of conducting sieges, which, although intimately connected with elementary fortification, is best treated as a distinct subject. It may therefore suffice to say, that repeated experience has fully proved, that a besieging army attacking the main inclosure of a fortress, ought, in preference, to direct their operations against the bastions, not against the tenails and curtain. This being the case, the only thing essentially necessary in the construction of a tenail, is to make it so low, that the flanks shall be able to fire over it into that part of the main ditch, which is in front of the bastions; because that is the only part, where it is convenient for a besieging army to effect their passage, in assaulting the body of the place.

To explain this observation more fully, draw a front of fortification with a simple tenail. Mark the right flank by the letters, a b; the opposite or left face by the letters, c d; and the reentering angle or center of the tenail by the letter, e: and dot the unmarked parts of the line of defence, a d.

Lastly, from the point, a, on the line, a d, set off a distance, a f, equal to three times, a e.



Then if we suppose, as before, that the parapet of the body of the place is thirty-six feet higher than the bottom of the main ditch, but that the tenail is only eighteen feet high above the same level; it follows that the body of the place will have a command of eighteen feet over the tenail. Consequently a shot fired towards d, from the point, a, of the flank, a b, at such an angle downwards, as just to clear the parapet of the tenail, will drop or sink eighteen feet nearly in the distance, a e: and at double that distance it will of course drop about eighteen feet more, which will bring it down to the level of the bottom of the ditch.

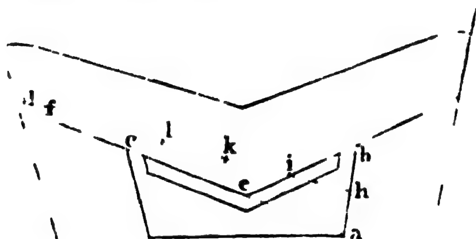
But from the construction of a regular front of fortification, the distance, a c, is rather more than double of a e. And therefore, a musquet shot, fired from the inward extremity of the flank, a b, so as to clear the parapet of the tenail, may strike the bottom of the main ditch, near the point, c, at the shoulder of the opposite bastion; so that the whole of the ditch of the face, c d, of that bastion may be seen into by the fire of the flank, a b.

But if we suppose the parapet of the tenail to be raised to the height of twenty-four feet, above the level of the ditch; then the body of the place would only have a command of twelve feet over it. Consequently a shot fired from the flank at a, so as to clear the parapet of the tenail, would only drop about twelve feet in the

distance, a e; and therefore it would have to fly three times the distance, a c, that is as far as the point, f, before it could drop so low as to meet the level of the ditch.

It therefore follows, under our present supposition, that the point, a, of the flank, a b, instead of commanding the whole of the ditch of the face of the opposite bastion, as before, would only be able to see into a very small part of it, f d, near the salient angle.

Those parts of the flank, which are nearest to the angle of the shoulder, are less impeded in their fire by the tenail, than other parts of it. For instance, take a new point, h, nearer to the angle of the shoulder; and from thence draw a dotted line, h l, towards the salient angle of the opposite bastion, intersecting the tenail in the point, i. Upon this line, set off the distance, h k, equal to twice h i, and, h l, equal to three times, h i.



Then to return to our first supposition, namely, that the body of the place has a command of eighteen feet over the tenail; a shot fired from h, towards the salient angle of the opposite bastion, so as to clear the parapet of the tenail, will be able to strike the level of the ditch nearly at the point, k, that is to say, at about twice the distance, h i. This is much nearer than c, which, as before stated, is the nearest point that it is possible to strike, on the level of the ditch, by a shot fired from a.*

* In a finished plan, the points, a, and h, ought to be taken upon the interior (not on the exterior) crest of the parapet.

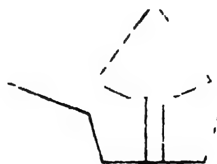
But if, according to our second supposition, the body of the place has a command of twelve feet only over the tenail; then a shot fired from h, so as to clear the parapet of the tenail, may strike the bottom of the ditch near the point, l, that is to say at about three times the distance, h i. This again is much nearer than f, which, as before stated, is the nearest point of the ditch, that it would be possible to strike by a shot fired from a, under the same supposition.

I shall here remark, that in the bastionary system of fortification, as well as in the redan system, the term flanked angle is often used to denote a salient angle. Thus, for instance, the salient angle of a bastion is often called THE FLANKED ANGLE OF A BASTION.

The term flanking angle is also used in the bastionary system. It applies, however, not to any angle, which actually appears in the outline of the fortress, but to those imaginary angles, which are formed in each front, by the meeting of the flanks, and of the lines of defence; or in other words by the meeting of the flanks, and of the faces produced. Thus in our present figure, for instance, the angle, b a d, which is formed by the meeting of the flank, b a, and the line of defence, a d, is one of THE FLANKING ANGLES OF A REGULAR FRONT OF FORTIFICATION, thereby represented.

To return to our former subject, namely the consideration of the command of the flanks; it is to be observed that in those parts of a fortress, which have principal gateways and bridges of communication towards the country; their fire, I mean the fire of the flanks, will always be more or less obstructed by the bridge, in proportion to its height.

Draw a new figure representing a front of fortification, with a bridge extending perpendicularly from the center of the curtain across the main ditch.



Now if, as before, we suppose the body of the place to be thirty-six feet high, but the bridge to be only eighteen feet high, above the level of the ditch; then a musquet ball, fired from either flank so as just to clear the bridge, will strike the ditch at about twice the distance of the further side of the bridge; which, from the construction of a regular front, will of course be at some point nearly in front of the opposite angle of the shoulder, or rather a little beyond it. Consequently, under this supposition, the flanks will be able to see into nearly the whole of that part of the main ditch, which is in front of the bastions.

In most fortresses, the principal bridges are raised to the level of the original ground line, which is generally about half the height of the parapet of the body of the place, or nearly so, in conformity with the above supposition. The gateway in the curtain being of course bodily elevated above this level, it follows that if the tenail is raised to such a height as completely to cover the principal gateway, it cannot be much lower than the body of the place itself.*

For instance, suppose as above the body of the place to be thirty-six feet high; and the bridge, and consequently the pavement of the gateway, to be half that height, that is eighteen feet high above the level of the ditch. In a principal communication, the height of the gate itself cannot be estimated at less than fifteen feet more: to cover which would consequently require a tenail thirty-three feet high, that is only three feet lower than the body of the place. But, by a tenail elevated to such a height throughout, the fire of the flanks would be so much obstructed as to be rendered almost totally useless.

* If troops man the tenail, the fire of the flanks must necessarily be directed higher than has been supposed in the text; and a part of their command over the ditch will consequently be lost.

It appears therefore best, entirely to give up the idea of screening the principal gateways of a fortress by tenails of the form described in this book.* The utmost that can be expected from them is to cover the lower part of the revetments of the curtain and flanks, in such a manner, that it shall be impossible for an enemy to effect a practicable breach in these parts of the body of the place, until he has taken or destroyed the tenail. As far as regards the bridges, the lower that they can be kept, without material inconvenience to the communication, the better will it be for the purposes of defence.

The considerations, which have been discussed in this chapter, are of great importance in determining the reliefs of the various parts of a fortress; and will account for the difference, before alluded to, which may be observed between the profiles contained in this book, and those that are to be found in other writers on fortification.

REMARK.

By reflecting upon what was said in that part of our present chapter, which treated of the comparison between ancient and modern fortification, it will appear evident, that the prevailing system of fortification amongst civilized nations, at any particular period, must always depend upon the nature of the means of attack then known, according to which it must be chiefly regulated.

* Tenails have sometimes been made of a different form, for instance with long curtains and flanks parallel and near to those of the body of the place; and when constructed in this manner, they obstruct the fire of the flanks less than the common kind of tenail, supposing the height of each to be equal. It will of course be understood, that although incapable of covering a principal gateway, a tenail of very moderate height may be able to protect posterns or sallyports; these, in dry ditches, being usually placed at the very foot of the scarp revetment, and, in wet ditches, as low as the water will permit.

Thus as the general use of gunpowder, in war, led in a short time afterwards, to the adoption of the bastionary system, which forms the grand criterion of modern fortification; if we could conceive, at any future period, the use of cannon to be entirely lost amongst mankind, then our present fortresses, although by far the best under existing circumstances, would immediately lose their superiority, and it would be necessary once more to return to the high walls and towers of antiquity, which under the above supposition would be a great deal stronger, and preferable in every respect.

CHAP. XV.

EARTHEN RAMPARTS, OR RAMPARTS WITHOUT REVETMENTS, DEMIREVETMENTS, AND FULL REVETMENTS, EXPLAINED. — OBSERVATIONS ON THE OBSTACLES, USUALLY EMPLOYED, TO STRENGTHEN EARTHEN WORKS.

In marshy ground, or in situations, where water may be found by digging a certain number of feet below the surface, fortresses have sometimes been constructed with earthen ramparts only, without revetments of any kind; in which case, their principal defence against an assault consists in the wet ditches, which have necessarily been formed to protect works of this description.

A mound of earth, even of the firmest kind, cannot for any length of time stand perpendicularly like masonry; and the higher it is raised, the less capable it will become of preserving this position. Unless supported by some kind of retaining wall, or in other words, unless it is reveted, it must therefore be formed with slopes on every side, in order to enable it to maintain any permanent figure.

Earth varies considerably in its quality, so that some kinds of it

will stand with a much smaller slope than others. Common earth will stand at an angle of 45°; that is to say, at a slope whose base is equal to the height. Loose earth or sand requires the base of the slope to be greater than the height. Very stiff earth, in proportion to its tenacity, will stand at a slope whose base is three fourths or even one half of the height.

When the height is small, it may be remarked that the same kind of earth will stand much steeper, than if the height were considerable. For instance, supposing a rampart to be formed entirely with earth, the interior slope of the parapet might perhaps stand with a base of one half its height, whilst the scarp or exterior slope of the rampart could not be considered secure with less than a base equal to its height, in consequence of the scarp being five or six times as high as the parapet.

In order to avoid unnecessary repetitions of the words "base" and "height," it is usual to express a slope by two proportional numbers, of which the first always applies to the base, and the second to the height.

For instance a slope of 1 to 1, denotes a slope of 45°, or one whose base is equal to its height.

A slope of 1 to 2, denotes one, whose base is one half of its height.

A slope of 6 to 1, denotes one whose base is six times the height.

A slope of 9 to 7, denotes one whose base is to its height in the proportion of 9 to 7, &c. &c.

Sometimes a slope may be described in a still more concise manner, by using one number only, which may either be an integer or a fraction, for the purpose of denoting it. The number mentioned always applies to the base of the slope; and denotes its proportion to the height, which in this case is always supposed to be represented by an unit.

For instance, when a slope is simply said to be a slope of one third, it implies one whose base is one third of the height.

A slope of two thirds, implies one whose base is two thirds of the height.

A slope of six, denotes one whose base is 6 times the height.

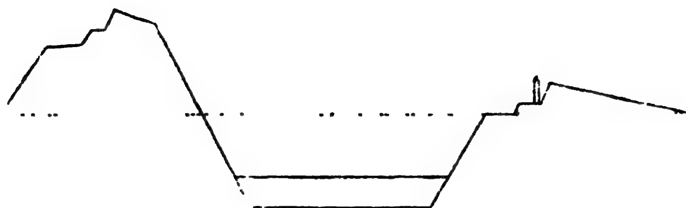
A slope of twenty four, denotes one whose base is 24 times the height, &c. &c.

Taking into consideration, that the ramparts of a fortress ought to have about thirty feet perpendicular height at the least, one cannot, even in favourable soil, depend upon so great a mass of earth retaining its form for any length of time, unless the base of the exterior slope is made equal to the height or nearly so. Experience has proved that such is the least average slope, which can be allowed to earthen works in general, although exceptions may of course occur in particular cases. But it is perfectly practicable for men to run or scramble up an earthen slope of the above proportion, particularly after it has been exposed to the effect of batteries; and hence follows the necessity, above stated, of securing earthen works by wet ditches or other additional obstacles, without which they, in themselves, could not be deemed tenable against an assault.

We shall now proceed to exemplify, by proper figures, the sections of a fortress, supposed to be constructed with earthen ramparts only.

Draw a line for a ground line, upon which construct a rampart, ditch, covered way, and glacis, in the usual manner in other respects, but without any revetments or counterforts; representing the scarp and counterscarp by oblique lines, sloping in the proportion of 1 to 1 nearly; and drawing the former, that is to say the scarp, in one continued right line, from the exterior crest of the parapet to the bottom of the ditch, without any berm.

Draw also a right line to represent the surface of the water, in the wet ditch.



When there is a wet ditch, it is usual to allow a berm on each side, a little above the surface of the water, in order to prevent the scarp and counterscarp from being injured or undermined by it. Moreover, as the action of water is more destructive to earthen works than the common effects of air and weather, it is also usual to give to those slopes, which are under water, a greater base in proportion to their height, than is allowed to the other slopes of the fortress.

You will therefore alter your figure accordingly, representing a berm on each side, a little above the surface of the water; and in drawing the new banks of your wet ditch, give the slope of each a greater base in proportion to its height, than was allowed before.



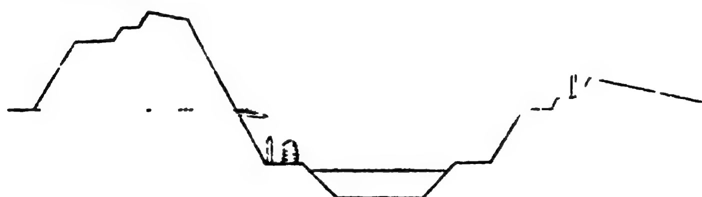
As earthen works have very little power in themselves of resisting an assault, they are often strengthened, not only by wet ditches, but also by other means, such as palisades, fraises, hedges, &c.

The nature of palisades has already been explained.

FRAISES are strong pointed stakes, exactly resembling palisades, with this difference only, that they are fixed horizontally or nearly so, whilst the palisade is planted vertically. It is usual to give fraises a very small inclination downwards, in preference to any other position.

QUICKSET HEDGES are also often used to increase the strength of earthen works.

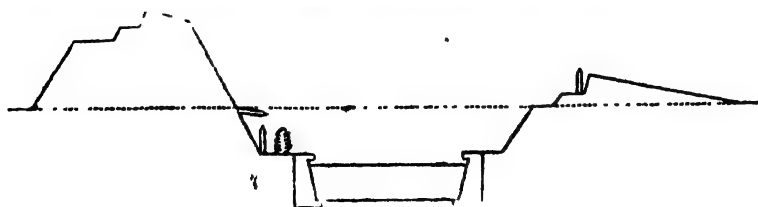
In order to represent all these expedients in your present figure, draw a fraise projecting from the scarp a little below the ground line, and pointing in a small degree downwards. On the front of the berm of the scarp, draw a figure to represent a quickset hedge, in rear of which draw a palisade. Draw also a palisade on the covered way.



The section of A FORTRESS WITHOUT REVETMENTS is now complete.

Sometimes there is a revetment, on each side, for the banks of the wet ditch only. Then the place is said to be constructed with water revetments.

Draw small revetments, on each side, for the banks of your wet ditch, placing the top of each on the same level with your berms.

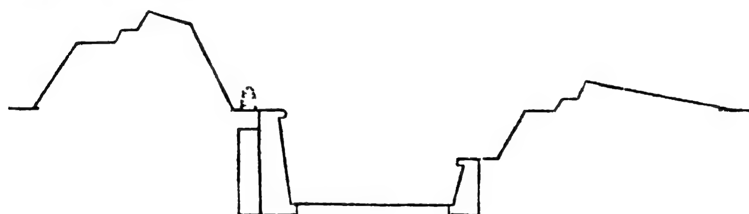


The section of A FORTRESS WITH WATER REVETMENTS is now complete.

Sometimes a rampart may be constructed with demirevetments, or half revetments, which implies that the lower half of the scarp only is reveted.

Rub out the lower part of your scarp, from the fraise downwards, in place of which draw a revetment with a broad berm at the top of it, and a counterfort. Make the counterfort lower than usual and draw a hedge upon the berm in rear of the revetment.

Rub out the imaginary parts of your ground line, and draw a dotted horizontal line, backwards, from the crest of the glacis, meeting the scarp.



The section of A RAMPART WITH DEMIREVETMENTS is now complete.

By inspecting this figure, you may observe, that the glacis effectually covers the whole of the demirevetment, as also the lower part of the earthen slope of the scarp, so that it would be impossible for an enemy, to strike those parts of the rampart, which are below the dotted line, by cannon shot fired from batteries constructed any where beyond the glacis.

It will likewise be evident, that all that part of the scarp, which is below the dotted line, might be reveted, without exposing any masonry to the fire of distant batteries; and in that case the rampart would be much stronger than it is at present, for the higher a revetment is, the more difficult it becomes to take it by escalade

In scaling a work, the ladders ought to be of such a strength, as to support the greatest possible number of men, who can conveniently stand or move upon them. If this precaution is neglected, and the ladders are made so weak, that only two or three men can ascend at the same time with safety, whilst the others must wait below, till they reach the summit; these unsupported individuals may easily be overpowered in case of resistance: or what is more probable, in the ardour and confusion of the assault, the men ordered for that duty will rush on, regardless of the weakness of their ladders, the whole or the greater part of which will consequently break down, and the enterprise will fail.*

But when revetments are thirty feet high and upwards, ladders, having the requisite strength for a vigorous escalade, will become so very unwieldy, that if we take into consideration the whole process, first, of carrying them across the glacis, secondly, of descending the counterscarp by means of them, and afterwards of planting them against the scarp revetment, and mounting upon the parapets of the body of the place; it becomes altogether a task of such labour and difficulty, that unless the garrison of the place attacked should be culpably and unaccountably negligent, a thing which it is not fair to calculate upon in war, the success of such an enterprise is next to impossible.

When the revetments of a fortress are very low, 10 or 12 feet for instance, then light manageable ladders, which may be carried and planted with great ease, will be strong enough for the purposes of escalade. Such places, therefore, particularly if they have no

* Of all scaling ladders of equal length, that can be used in assaulting a place, those which are made with a number of joints, each about five or six feet long, under an idea of portability, are the worst and weakest. At least I can say, from experience, that the scaling ladders of this description, which form an article of store in the British service, are bad, and not to be depended upon. Accidents have frequently happened in using them

counterscarp, or a very low one, are liable to be taken by a general assault, and, in consequence of the weakness of their profile, they can never be considered secure, without very powerful and vigilant garrisons.

One of the first and most essential objects, to be attended to, in planning a fortress, is to render it secure against a surprise or sudden assault; so that an enemy can have no hopes of taking it but by the tedious, expensive, and laborious process of a regular siege. In places with dry ditches, this depends principally or entirely upon the height of the revetments, both of the scarp and counterscarp. Consequently, as far as the above object alone is concerned, the scarp revetments of a fortress can scarcely be made too high: and therefore, in cases where demirevetments have been used, it has been done solely from motives of economy, the lowest revetments being invariably the weakest.

It has been judged best, however, not to make the top of the scarp revetment of a fortress higher than the level of the crest of the glacis, as represented by the dotted line in our present figure; because if raised above that level, a part of the masonry would be liable to be injured by the fire of distant batteries.

In conformity with this rule, in the first figure of the sections of a regular fortress, which you drew by scale, *(See Chap. VI, and Plate 2d.)* the scarp revetment, exclusive of the cordon, is made thirty-one feet high, above the level of the ditch. This exactly agrees with the height of the crest of the glacis, which is nine feet higher than the ground line, whilst the latter is twenty-two feet above the level of the ditch, making thirty-one in all.

From hence, it may appear, that, generally speaking, if the above rule is attended to, the scarp revetments of the main inclosure of a fortress cannot be made much more than thirty feet high, which in a commanding profile, such as those contained in this book, will extend about two thirds of the height of the scarp only; but in a less commanding profile, such as is more usually

recommended, it may extend three fourths of the total height of the scarp, or even more.*

The rule, which has just been stated, of reveting only a part, not the whole of the scarp, has not always been followed in modern fortification. A contrary practice prevailed, even after the period, that the outline of the bastionary system had been brought to considerable perfection.

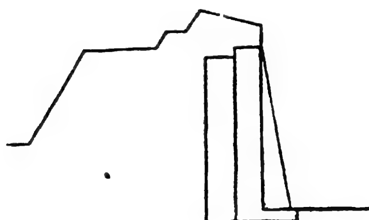
When the whole of the scarp is reveted, a rampart is said to have full revetments.

We shall proceed to exemplify this method, by drawing the section of a rampart so constructed.

Draw part of a rampart, in the usual manner, including the interior slope, the terreplein, the banquette, and the whole of the parapet, excepting its exterior slope only.

From the exterior crest of the parapet drop a perpendicular for the total height of the scarp. Upon this perpendicular, as a scarp line, construct a revetment, the top of which must not, however, reach quite so high as the top of the perpendicular itself; and let the difference of height be about equal to the height of the banquette.

Draw also a counterfort to your scarp revetment, in the usual manner.

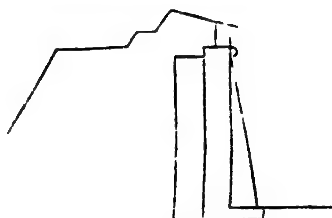


* In Cormontaigne's profile, the scarp revetment is 32 feet high, exclusive of the cordon; the total height of the scarp from the level of the ditch to the exterior crest of the parapet being 40 feet 6½ inches nearly. Other French writers, who are advocates for the grazing system of fire, make their scarp revetments 32 feet high, in a scarp of 36 feet 6 inches.

The top of the scarp revetment, in your figure, agrees nearly with the level of the bottom of the parapet. The short perpendicular above it represents the front of the parapet, which, in this construction, must also be reveted; but the wall, built for that purpose, is usually made a little thinner than the top of the scarp revetment.

Draw the back of the exterior revetment of your parapet, as above described, parallel to the front of it; but not extending quite so far to the rear, as the back of the scarp revetment.

This being done, draw the projection of a coping, at the top of THE EXTERIOR REVETMENT OF THE PARAPET; and draw that of a cordon, at the top of the scarp revetment.



Rub out superfluous lines in your revetments; complete your section, by drawing a ditch, covered way, and glacis, in the usual manner; and draw a dotted horizontal line, from the crest of your glacis backwards, meeting the scarp.



The section of A FORTRESS WITH FULL REVETMENTS, that is to say, with the whole of the scarp reveted from top to bottom, is now complete.

A place, so constructed, by reason of the extraordinary height of its walls, is very secure against a sudden assault; but it labours

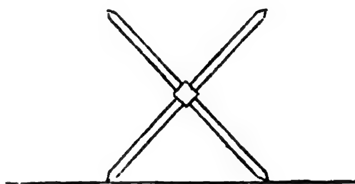
under a great disadvantage in case of a siege. The whole of that part of the masonry of the scarp revetments, which is above the dotted line or level of the glacis, is completely exposed to the fire of distant batteries; and this, according to the usual profile given to a rampart, would form on an average not less than one third of the total height of the wall. The same objection, therefore, applies in some degree to this construction, which was urged, in the foregoing chapter, against the high naked walls of antiquity. The besiegers might, by a distant fire, completely ruin the upper part of the full revetment, which in its fall would bring down nearly the whole of the parapet along with it.* Consequently, although a practicable breach could not thereby be effected; yet the principal defences of the fortress might be almost completely disabled in a few days, so that an enemy might carry on the ulterior operations of the siege, comparatively speaking, with far less difficulty and loss, than would necessarily be incurred in attacking any other fortress of the same relief and outline, but with scarps only in part reveted.

Field works are always constructed with earth, and most frequently commanding situations, such as the summit of heights, &c. are chosen for them. In such positions they can seldom be secured by wet ditches; and therefore their principal strength depends upon palisades, fraises, and other obstacles of a similar nature. One of these contrivances, called chevaux de frize, shall be described here, being often employed, not only in field fortification, but also in permanent works.

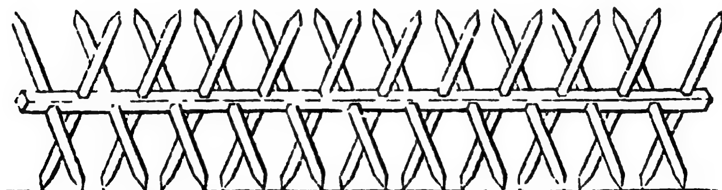
* Vauban, who built his fortresses with full revetments, generally gave the rampart a command of about 14 feet 6 inches over the crest of the glacis. Making some deduction for the dip of the parapet, there must therefore have been about 11½ or 12 feet of masonry, completely exposed by this construction.

Chevaux de frize consist of strong pointed stakes, usually set up at intervals of six or eight inches apart; in such a manner as to cross each other in the form of a St. Andrew's cross, with the upper or projecting points raised to the height of about five and a half or six feet from the ground. As they are not usually driven into the earth, they are let into a stout beam of timber, by means of tenons and mortises made for the purpose. This beam forms the center of the cross, and keeps a considerable number of the stakes together. The latter are commonly called the spears. Any one beam, with the spears attached to it, forms what is called a stand of chevaux de frize, which may be made of any length that is judged most convenient. The points of the spears are generally shod with iron.

The section of A STAND OF CHEVAUX DE FRIZE is as follows, in which THE BEAM is represented by the square in the center of the figure. THE SPEARS are also represented.

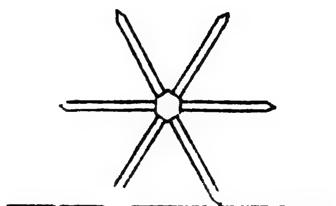


To illustrate still more clearly the nature of this obstacle, the oblique elevation of a stand of chevaux de frize is added.



Chevaux de frize are not always made in the manner represented in the above figures. Sometimes a greater number of projecting

spears are used, in which case the beams are not cut square but hexagonally. The section of a stand so constructed is as follows.



Chevaux de frize, when used in permanent works, are generally placed on the berms of fortresses having earthen ramparts or demirevetments.

A barrier, for the purpose of shutting up a road of communication, is sometimes formed by a stand of chevaux de frize, in which case, the stand is made to traverse or move round on a pivot. The motion of A CHEVAUX DE FRIZE BARRIER is facilitated by means of a wheel, or wheels, fixed either to one or to both ends of the beam, as to an axle tree, whichever may be judged most convenient; and the spears do not quite reach the ground at bottom, in order to prevent them from impeding the motion.

In strengthening works by chevaux de frize, the various stands are set up in the same allinement to the extent required, and the ends of the beams of the adjoining stands are chained, or otherwise firmly fixed together, by iron work. To give greater firmness, the ends of the lower spears may, if it is judged proper, be let into the ground; for which purpose they should, in that case, be made a little longer than the upper ones.*

* Portable chevaux de frize were common in former times, and in the British service they still form an article of store in the Engineer Department of the Ordnance. The beams and spears of these portable chevaux de frize are made lighter and shorter than usual; and they are stowed away, in a compact manner, in large casks, with the means of putting them together, when required.

CHAP. XVI.

OF THE GENERAL RULES AND PROPORTIONS, WHICH OUGHT TO BE OBSERVED, IN DETERMINING THE OUTLINE OF A BASTIONARY FRONT OF FORTIFICATION.—EXPLANATORY TABLES AND REMARKS.

It was before stated, that the length, and other dimensions, of the various parts of a bastionary front of fortification, are susceptible of some variation; but that there are certain limits, beyond which any further increase or diminution of the magnitude of any particular part would be prejudicial.

In determining the proportions of a regular front of fortification, the following objects are desirable.

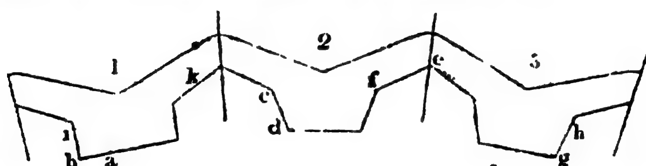
1st. That the curtain shall be of such a length, as to admit of one half of it being properly defended by the right flank, and the other half of it by the left flank, of the adjoining bastions.

2d. That the length of the lines of defence shall not exceed the range of musquet shot, in order that an enemy assaulting any part of the body of the place may be exposed to an enfilading fire, not only of artillery but also of musquetry from the flanks.

3d. It has been laid down as a rule in fortification, that whenever the face of a work is intended to fire in any particular direction, it should be constructed at right angles to the said direction, or nearly so. If this is not attended to, the line of fire both of cannon and musquetry, acting from the work, will become oblique, which is a great disadvantage; for gun batteries with oblique embrasures are more troublesome to construct, and weaker than others, as shall afterwards be explained: and as far as regards the

service of musquetry, it is at all times very inconvenient for a line of troops to fire obliquely; and in the confusion attending a general assault, particularly at night, they seldom can be made to present otherwise than straight before them, so that the greatest part of their fire on such occasions, if required in an oblique direction, might be uselessly thrown away.

For this reason, when any work is intended to flank another, the former should be laid out perpendicularly, or nearly so, to the face, which it is to defend. But in applying this rule to the bastionary system, as the flank has to protect not only the face, but also the curtain, it evidently cannot be made perpendicular to both. In the early periods of modern fortification, it was usual to make the flanks at right angles to the curtain, in the manner represented in front, No. 1, of the annexed figure. Afterwards it was found, that the defence of the faces of the bastions was of more importance than that of the curtain, the former being most liable to an assault, in case of a regular siege; and therefore the flanks were made perpendicular to the faces produced, or nearly so, as represented in fronts No. 2, and 3, of the same figure.



When the flanking angle, c d e, is a right angle, the opposite face, e f, is said to be defended by a grazing fire.

In front No. 1, on the contrary, the faces are defended by a plunging fire, as is shown by the line, i k, supposed to denote the path of a musquet ball fired from the point, i, in the flank, i b, to protect the opposite face.

Front No. 3 shows Vauban's method, which has been generally approved, in which a line, e h, drawn from the point of a bastion

to the center of the opposite flank, is at right angles to it; so that the flanking angle, e g h, is acute in a small degree. Hence the fire of the flanks, in No. 3, is more plunging than that of front No. 2. The advantage of this construction is, that flanks having a moderately plunging fire will be able to see into any breaches, that may be effected in the faces of the opposite bastions, in case of a siege, rather better than if they acted with a grazing fire only.

In the imperfect construction of the bastionary outline, used in the early periods of the art, the lines of defence did not terminate upon the extremities of the curtain, but upon some central point of it, such as, a, in No. 1; so that a certain portion of the curtain, a b, assisted in flanking the opposite face, in an oblique imperfect manner. For this reason, it was usually called THE AUXILIARY FLANK.

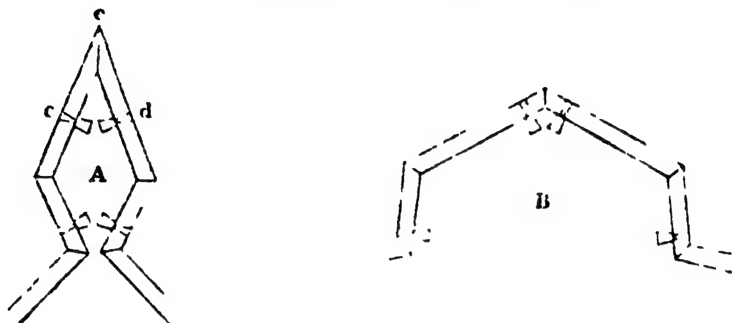
4th. The faces and flanks of the bastions should be extensive, so as to admit of a powerful combined fire of cannon and musquetry.

5th. The interior of the bastions should be spacious, in order to allow sufficient room, for the movement of guns, carriages, and troops, in various directions, without interfering with the manœuvres of the guns placed in battery upon the ramparts; as also for the formation of traverses and splinter proofs, in convenient situations, for a protection against the effect of the enemy's enfilading batteries and shells. Spacious bastions are likewise preferable in another respect, inasmuch as they may be more advantageously defended by means of interior intrenchments towards the gorge, than is practicable in smaller ones.

6th. The salient angles of the bastions should always be made as obtuse as circumstances will permit.

The advantages of this construction will be evident, on inspect-

ing the annexed figure, in which two bastions are represented, whose faces and flanks are exactly of the same length, but of which the one is very obtuse, and the other very acute.



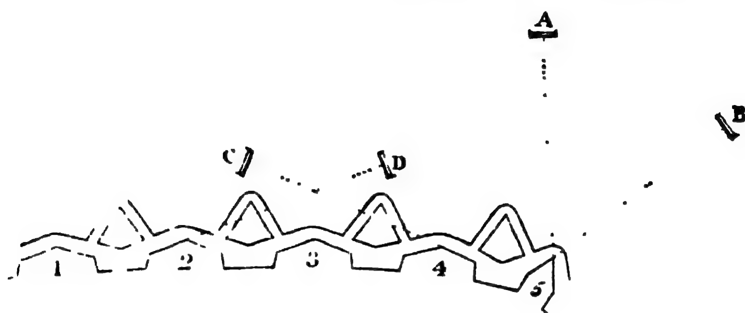
In the acute bastion, A, it appears, that it is quite impossible to place gun batteries nearer to the salient angle, e, than the points, c, d, and thus a considerable portion, c e, and d e, of each face, is rendered useless for the service of artillery. The width of the gorge is also contracted to a most inconvenient degree, so that there would not be a proper passage for troops, guns, &c.; and the interior capacity of the bastion is so small, that the men who may be ordered to defend it, being crowded into a narrow space, will not only be cramped in all their movements, but will also be exposed to much greater danger from an enemy's fire, particularly of shells, than would be the case in a larger work.

In proportion to the acuteness of the salient angle, it will also be evident, that the masonry near the point of the bastion must be weakened, and rendered the less capable of resisting the effect of an enemy's breaching batteries.

In the obtuse bastion, B, on the contrary, it will be seen, that none of these disadvantages occur. Guns may be placed in any part of the faces and flanks without inconvenience; and there is no want of space, for any useful purpose, in the interior or towards the gorge.

There is another very great disadvantage attending acute bastions. They are by far the most liable to injury from an enemy's enfilading batteries, in the event of a siege.

This will be understood by examining the annexed figure, which represents part of the outline of a fortress, consisting of five bastions, whereof the first four are obtuse, but the fifth is acute.



A and B show the position of batteries, which may be supposed to be established, by a besieging army, for the purpose of enfilading the faces of the acute bastion No. 5. C and D, in like manner, represent batteries, established for the same purpose, against the right face of the obtuse bastion No. 4, and against the left face of the obtuse bastion No. 2.

Now if we suppose the whole of the above batteries to be placed at about 600 yards from the points of the bastions, against which they are directed; it will be evident, by inspecting the figure, that the batteries, A and B, are exposed to a direct fire only, whereas the batteries C, D, are exposed not only to a direct fire, but also to an enfilading and reverse fire, from the works of the fortress, at a much shorter distance.

Thus the enfilading batteries, erected by a besieging army against acute bastions, may effect their object with little loss; whereas batteries, established for the same purpose, against obtuse

bastions, must necessarily be placed in more disadvantageous situations, where they may be exposed to a cross fire of the most destructive nature, acting upon them in front, in flank, and in rear.

In some few cases, circumstances may admit of bastions being constructed with such very obtuse salient angles, that an enemy's enfilading batteries, C, D, may not even be able to have a proper direct view of the faces of the bastions, but must fire over some intervening ravelin, as is represented in the figure. Bastions of this description can receive little or no injury, from the enfilading fire of such batteries.

From the above considerations, it has been laid down as a rule, that the salient angles of works in general should not be less than 60°; and as far as regards those of bastions in particular, it may be allowed, that the more obtuse they are made, the better will it be for the purposes of defence, provided that no other essential object is sacrificed, in so doing.

REMARK.

In fortified polygons, whose exterior sides are of equal length, the salient angles of the bastions are always more obtuse in proportion to the greater number of sides; and it has just been explained, that this adds to the strength of a fortress. Consequently the front of a decagon is stronger than that of a pentagon, but weaker than that of a dodecagon, supposing that all the three are fortified according to the same system.

There is also another reason, which makes a large fortress stronger than a small one, in proportion to its extent; namely, that the former, when besieged, requires a greater degree of labour in forming proper approaches, &c. against it, than the latter, as will be easily understood, when you come to study the plan of attack of a regular fortress.

Having now stated the various objects, which are of importance, in planning the outline of a bastionary front; it is proper to remark, as a thing, which invariably holds good in fortification, that any one acknowledged and indisputable advantage, if carried too far, will always produce some inconveniency or evil, which will counterbalance it.

For example, in a foregoing chapter, it was explained, that in ramparts of equal height, a full revetment is much stronger against a sudden assault than a partial or demirevetment; but then it was also shown, that the latter is infinitely more capable of resisting an enemy's batteries, and, as having less masonry, it is also the least expensive.

To apply the same general remark to our present subject, it will be evident, that if the exterior side of a front of fortification is longer than usual, the bastions may in consequence be made more extensive and spacious, which will so far be of advantage; but by such a construction, the lines of defence will also be lengthened in the same proportion, so that an enemy assaulting the bastions might be out of range of musquet shot from the flanks. Hence a very great evil would arise.

Again, by shortening the perpendicular of a front of fortification, the salient angles of the bastions will be rendered more obtuse, which will be advantageous to the defence; but then the diminution of the flanks, necessarily caused by this construction, will have a contrary tendency.

Moreover, by diminishing the length of the faces of the bastions, when the exterior side is of a given length, the flanks will be increased, which is an advantage; but the lines of defence will, at the same time, be lengthened, a thing which, as was before explained, is by no means desirable.

Thus by increasing the magnitude of any part of a front of fortification of a given length, the dimensions of some other part of it must necessarily be diminished, and vice versa; and as there are limits, beyond which the dimensions of any particular part cannot be increased or diminished without prejudice to the strength of the fortress, it follows, that there must be a certain medium length for the various parts of the outline of a bastionary front, which, upon the whole, will be the most advantageous for the purposes of defence.

Engineers have, however, varied in their opinion, as to the proper medium length, and form, of the various parts of the outline: and a number of different systems of fortification, before alluded to, have accordingly been proposed. But it has been very generally allowed, that an exterior side of about 384 yards, a perpendicular of about one sixth of the exterior side, and bastions whose faces are about two sevenths of the exterior side in length, form a well-proportioned simple front; and these dimensions constitute what has been called the first system of Vauban, the construction of which has been illustrated in the 5th and 13th chapters of this work.

The above proportions, however, strictly speaking, are only suitable to hexagons or polygons of a greater number of sides. If used in the construction of the pentagon or square, the salient angles would thereby be rendered too acute, and the gorges too narrow. It has therefore been judged best to give to the pentagon a perpendicular of one seventh, and to the square a perpendicular of one eighth, of the exterior side only.

In the annexed Table, marked No. I, the first line gives the dimensions of the various parts of one front of Vauban's first system, as above explained; the remaining lines show the varia-

tions, which would be produced in the above front, by diminishing the length of the perpendicular, from one sixth to a smaller proportion, without changing any of the other parts. The width of the gorge is calculated, as it would appear in a simple outline, and consequently a deduction must be made for the thickness of the parapets of the opposite flanks, &c. in order to find its actual width.

A second Table has also been annexed, to show the further variations, which would be produced in a front, whose exterior side is of the same length, as above supposed, by altering not only the proportion of the perpendicular, but also the length of the faces of the bastions.*

I shall next notice some of the principal angles of a fortress, introducing a few simple rules for finding them.

* The lengths of the flanks, curtains, and lines of defence, as well as the total length of the outline of each front, given in the various tables, contained in this chapter, have been found by geometrical construction, not by calculation; and therefore it will be understood, that I do not vouch for their accuracy to any very great degree of nicety. They are, however, correct enough for any useful practical purpose. In Table III, the various numbers are all laid down according to calculation, and are consequently much more minute, than is absolutely necessary. If a rough calculation only should be required, time will therefore be saved, in using that Table, by rejecting as many decimals as may appear convenient.

The Learner is recommended to exemplify some of the principal variations contained in the 1st, 2nd, and 4th Tables of this chapter, practically; drawing by scale, first a front of fortification of the given length of exterior side, &c. and afterwards observing the changes produced in his figure, by increasing or diminishing the length of the perpendicular or faces. This will be more instructive than a mere reference to the Tables, which are chiefly calculated, to save trouble to those who are already masters of the general principles.

TABLE I.

Showing the Changes produced in a Front of Fortification, by varying the Length of the Perpendicular.

Length of the exterior side.	Face of the bastion.	Perpendicular. Proportional length.	Perpendicular. Actual length.	The flank.	The curtain.	Line of defence.	Length of the outline of one front.	In the Square. Salient angle of the bastion.	In the Square. The gorge.	Pentagon. Salient angle of the bastion.	Pentagon. The gorge.	Hexagon. Salient angle of the bastion	Hexagon. The gorge.
Yards.	Yards.	Parts.	Yards.	Yards.	Yards.	Yards.	Yards.	D. M. S.	Yards.	D. M. S.	Yards.	D. M. S.	Yards.
		$\frac{1}{6}$	64	55·7	151·2	281·0	482·6	53° 7 51$\frac{1}{3}$′	38·6	71° 7 51$\frac{1}{3}$	84·4	83° 7′ 51$\frac{1}{3}$″	112·6
		$\frac{1}{7}$	54$\frac{6}{7}$	47·5	153·8	279·4	468·8	58 6 33	54·0	76 6 33	95·0	88 6 33	122·2
384	110	$\frac{1}{8}$	48	41·8	155·0	277·8	458·6	61 55 39$\frac{1}{3}$	65·6	79 55 39$\frac{1}{3}$	106·0	91 55 39$\frac{1}{3}$	131·6
		$\frac{1}{9}$	42$\frac{2}{3}$	37·0	158·0	278·0	452·0	64 56 33	71·0	82 56 33	111·6	94 56 33	135·4
		$\frac{1}{10}$	38$\frac{2}{5}$	33·0	159·0	277·0	445·0	67 22 48$\frac{1}{3}$	82·2	85 22 48$\frac{1}{3}$	118·0	97 22 48$\frac{1}{3}$	141·6

TABLE II.

Showing the Changes produced in a Front of Fortification, by varying the Length not only of the Perpendicular but also of the Faces of the Bastions.

Length of the exterior side.	Perpendicular.		Face of the bastion.	The flank.	The curtain.	Line of defence.	Length of the outline of one front.	Length of the Gorge.			
	Proportion.	Actual length.						Heptagon.	Octagon.	Nonagon.	In the Decagon.
Yards.	Parts.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.
384	$\frac{1}{6}$	64	96	64·4	175·0	294·7	495·8	106·8	120·4	130·0	138·0
			110	55·7	151·2	281·9	482·6	133·0	146·4	156·0	164·6
			120	49·2	133·5	272·6	471·9	150·2	164·2	173·2	182·0
			128	44·2	120·0	265·0	464·1	164·4	178·0	187·4	196·0
Do.	$\frac{1}{7}$	$54\frac{6}{7}$	96	55·0	179·2	293·4	481·2	115·0	127·8	137·4	145·2
			110	47·5	153·8	279·4	468·8	141·4	154·0	163·6	171·4
			120	42·0	135·7	269·6	459·7	159·6	172·6	182·0	190·0
			128	37·6	121·0	262·0	452·2	175·0	188·0	197·8	205·8
Do.	$\frac{1}{8}$	48	96	47·2	182 0	291·8	468·4	122·0	133.0	141·8	148·8
			110	41·8	155·0	277·8	458·6	148·8	160·2	170·0	176·0
			120	36·7	137·2	268·0	450·6	166·0	178·0	186·8	194·4
			128	32·8	122·4	260·3	444·0	181·4	193·4	202·0	209·6

RULE I. To find the interior angle, or angle at the center, of any regular polygon: Divide 360 degrees by the number of sides, and the quotient will be the answer.

Thus in the decagon, 360° divided by 10, gives a result of 36 degrees, for the interior angle of that polygon.

RULE II. To find the exterior angle of any polygon: Deduct the interior angle from 180 degrees, and the remainder will be the answer.

Thus for instance, in the decagon, deduct 36° from 180°, and 144° will remain for the exterior angle of that polygon.

In fortified polygons of every description, when the perpendicular is one sixth of the exterior side, the diminished angle will be 18° 26′ 4″: when the perpendicular is one seventh, the diminished angle will be 15° 56′ 43½″. when the perpendicular is one eighth, the diminished angle will be 14° 2′ 10½″. at one ninth, it will be 12° 31′ 43½″: and at one tenth it will be 11° 18′ 36″.

RULE III. To find the salient angles of the bastions of any fortified polygon: Deduct twice the diminished angle from the exterior angle of the original polygon; and the remainder will be the answer.

Thus in the decagon, if the perpendicular is one sixth of the exterior side, deduct twice 18° 26′ 4″ from 144°, and the remainder, 107° 7′ 52″, will give the salient angles of the bastions.

But if the perpendicular of the above polygon had, for any reason, been made only one eighth of the exterior side; then from 144 degrees, deduct twice 14° 2′ 10½″, and the remainder, 115° 55′ 39″, will give the salient angles of the bastions of a decagon thus fortified.

To save the trouble of calculation in common cases, a third Table has been added, in which the radii, areas, and angles, of various regular polygons, are inserted.

TABLE III.

Showing the Radii, Areas, and Angles, of various regular Polygons.

Nature of the Polygon.	ORIGINAL POLYGON.						FORTIFIED POLYGON.		
	Exterior side.	Radius.	Proportional area	Proportional area in acres, when the exterior side is in yards.	Interior angle.	Exterior angle.	Perpendicular.	Diminished angle.	Salient angles of the bastions.
Square	1·000	0·7071	1·0000000	·0002066115	90° 00′ 00″	90° 00′ 00	$\frac{1}{8}$	14° 2 10$\frac{1}{2}$″	61° 55′ 39″
Pentagon . . .	Do.	0·8506	1·7204774	·0003554705	72 00 00	108 00 00	$\frac{1}{7}$	15 56 43$\frac{1}{2}$	76 6 33
Hexagon . . .	Do.	1·0000	2·5980762	·0002066115	60 00 00	120 00 00	$\frac{1}{6}$	18 26 4	83 7 52
Heptagon . . .	Do.	1·1523	3·6339124	·0007508083	51 25 43	128 34 17	Do.	Do.	91 42 [illegible]
Octagon	Do.	1·3066	4·8284271	·0009976809	45 00 00	135 00 00	Do.	Do.	98 7 52
Nonagon	Do.	1·4619	6·1818242	·0012772364	40 00 00	140 00 00	Do.	Do.	103 7 52
Decagon	Do.	1·6180	7·6942088	·0015897125	36 00 00	144 00 00	Do.	Do.	107 7 52
Undecagon . .	Do.	1·7701	9·3656399	·0019350495	33 43 38	146 16 22	Do.	Do.	109 24 14
Dodecagon . .	Do.	1·9318	11·1961524	·0023132546	30 00 00	150 00 00	Do.	Do.	113 7 52

Those columns of the third Table, which give the proportional radius and area of the various polygons in decimal parts, when the exterior side is equal to 1, will be useful in calculating the actual radius and area of any polygon of a given exterior side, that is to be fortified. The rules are as follow.

RULE IV. To find the radius of any polygon, whose side is of a given length, by means of Table III. Multiply the given side, by the proportional radius, marked in the Table opposite to the proper polygon, and the product will be the answer.

For example, supposing that a regular octagon of 384 yards side is to be fortified: multiply 384 by 1·3066, the proportional radius for that polygon; and the product 501·7344, or 501¾ yards nearly, will be the required radius.

RULE V. To find the area of any polygon, whose side is of a given length, by means of Table III.

METHOD 1. Multiply the square of the side by the proportional area, marked in the Table, opposite to the proper polygon, and the product will be the answer, in superficial measure, of the same denomination.

Thus, for example, in a regular octagon of 384 yards side, multiply 147,456, which is the square of 384, by 4·8284271, the proportional area for that polygon, and the product 711,980·546 gives the area of your supposed octagon in superficial yards, which may be reduced into acres by dividing it by 4840.

METHOD 2. When it is proposed to find the area of a regular polygon in acres at once. Reduce the given side into yards, if necessary, and multiply the square of it, by the number marked opposite to the given polygon, in that column of the Table which is entitled "proportional area in acres, &c." The product thereby found will be the answer.

Thus, for example, in a regular decagon of 1152 feet side; divide first by 3, to reduce it into yards, and 384 will be the quotient. Then multiply 147,456, the square of this number, by ·0009976089, and the product, 147·1034, which is equal to rather more than 147$\frac{1}{10}$ acres, will be the area of a regular octagon of 384 yards side, as required.

We shall next consider the variations that will be produced in a front of fortification, constructed according to Vauban's first system, by altering the length of the exterior side, without changing any of the other proportions.

Allowing the perpendicular to be $\frac{1}{8}$th of the exterior side, and the faces of the bastions to be $\frac{2}{7}$ths of the exterior side, according to the above system; then the proportions of the remaining parts will be very nearly as follows.

The flanks about $\frac{1}{7}$th
The curtain . . . . $\frac{2}{5}$ths
The lines of defence $\frac{11}{15}$ths
And the total length of the outline
of one front rather more than 1$\frac{1}{4}$
} of the exterior side.*

Hence in a front of 200 yards, fortified according to Vauban's first system, the faces will be about 57 yards; the flanks 28$\frac{1}{2}$

* By means of these proportions, the dimensions of the various parts of any front of a given length of exterior side, fortified according to Vauban's first system, may be expeditiously found, to such a degree of correctness, as will suffice for the purposes of rough calculation.

But if greater accuracy should be required, the exact length of the various parts may be ascertained by the following rule.

Multiply the length of the given exterior side, in yards, 1st by 0·286558, to find the faces of the bastions; 2dly by 0·145136, to find the flanks; 3dly by 0·393575, to find the curtains; 4thly by 0·734211, to find the lines of defence; and lastly by 1·256706, to find the total length of the front.

yards; the curtain about 80 yards; the line of defence about 146⅔ yards; and the total length of the outline of the front rather more than 250 yards.

In so small a work the flanks could barely mount 4 guns, and the faces about 8 guns, admitting the bastions to be rather obtuse; but if they are supposed to be acute, then the number of guns, capable of being mounted in each face, would be reduced in proportion. The curtain also will be rather too short to admit of its being properly flanked in every part, if the rampart is of a bold relief.

200 yards may therefore be considered the shortest regular front, that ought to be admitted in fortification; and that only in very small forts, such as square forts or pentagons, whose extent is either limited by circumstances, or which are of secondary importance.*

In larger fortresses, whose outline is formed of more extensive polygons, such as hexagons, heptagons, and upwards, it is desirable to make the exterior sides of the fronts in all cases at least 300 yards in length; but the nearer they approach to 384 the better.†

Authors have divided fortification into three different styles, which they term the mean, great, and little.

LITTLE FORTIFICATION implies that the length of the exterior side is about 320 yards, or less;

MEAN FORTIFICATION implies that the exterior side is about 384 yards;

* In Cumberland Fort near Portsmouth, a very well-executed pentagonal work, the principal front is 240 yards in length, the remaining fronts being each 200 yards.

† The principal fronts of Portsea Lines are each 360 yards in length.

And GREAT FORTIFICATION implies that the exterior side is about 425 yards in length. Vauban, however, to whom the use of these terms is ascribed, is said in peculiar cases to have constructed fronts of even 450 yards in length or upwards.

It was stated that the line of defence, in a place fortified according to Vauban's first system, is about [illegible]ths of the exterior side; consequently, in proportion as the length of a front so fortified varies from 300 to 400 yards, the line of defence will increase from 220 to 293 yards. Even at the former distance the common musquet is very uncertain in its effect; much more so at the latter. As far as the flanking musquetry defences alone are concerned, it would therefore certainly be desirable, to make the exterior side of a regular front considerably shorter than 384 yards, if other important considerations did not oppose it. At all events, it must be acknowledged, that it is always proper to have the line of defence as short as circumstances will permit; and therefore in fronts exceeding 384 yards, it has been laid down as a rule, that the length of the faces of the bastions should be increased from $\frac{2}{7}$ths to $\frac{1}{3}$d of the exterior side, or upwards.*

The following Table, marked No. IV, will show the changes produced in long fronts of fortification, by varying the length of the faces of the bastions; the perpendicular in all cases being supposed to be one sixth of the exterior side.

---

* The line of defence of a front of 384 yards, is nearly 282 yards in length; and the common infantry firelock is certainly by no means to be depended upon at such a distance. Wall pieces, or musquets of a superior quality, should therefore be kept in store in every fortress, to be issued, in case of a siege, to the troops defending the body of the place. For the service of the outworks and covered way, the common firelock may suffice.

TABLE IV.

Showing the Variations produced in long Fronts of Fortification, by increasing the Length of the Faces of the Bastions considerably beyond their usual Proportions.

Length of the exterior side.	Face of the bastion.	The flank.	The curtain.	Line of defence.	Length of the outline of one front.
Yards.	Yards.	Yards.	Yards.	Yards.	Yards.
390	110	57·2	156·0	287·7	490·1
	120	51·2	138·7	278·4	481·1
	130	45·0	[illegible]1·7	269·2	471·7
400	115	58·0	156·4	293·6	502·4
	125	51·5	139·4	284·8	492·4
	135	45·7	122·3	275·0	483·7
410	120	58·0	156·1	298·6	512·1
	130	52·0	139·5	289·5	503·5
	140	45·4	122·5	280·4	493·3
4[illegible]0	13[illegible]	54·7	148·8	299·9	5[illegible]2
	1[illegible]	48·3	132·0	290·5	508·6
	150	42·3	115·0	281·8	499·6
430	140	62·2	140·7	301·0	525·1
	150	46·0	124·0	292·0	516·0
	160	40·0	107·2	2[illegible]3·3	507·2
440	150	49·7	132·8	[illegible]2·4	532·2
	160	44·0	118·0	293·5	524·0
	170	37·7	100·0	285·2	515·1
450	160	46·3	124·3	303·0	536·9
	170	40·8	108·0	294·0	529·6
	180	34·6	91·8	286·0	521·0

REMARK.

$4\frac{1}{2}$ long fronts of $391\frac{1}{9}$ yards exterior side,
$4\frac{3}{4}$ fronts of $371\frac{1}{8}$ yards exterior side, or
5 short fronts of 352 yards exterior side,
} will exactly suffice to fortify one English mile in extent. If therefore the circumference of any city is given, you may easily find the nature of the polygon, which will be required to fortify it, by multiplying the given extent in miles, by any of the above numbers which you may judge convenient.

For example, supposing that the extent of any city or spot of ground, which is proposed to be fortified, and of which you have an accurate plan, proves by the scale to be two miles in circumference :* then if you multiply 2 by the above numbers, it will appear that 9 long fronts, $9\frac{1}{2}$ middling sized fronts, or 10 short ones, will exactly suit the given extent. But as the fraction of a front of fortification cannot be used in practice, it follows that in planning your supposed fortress, you must either adopt a long-sided nonagon, or a short-sided decagon.

Long fronts of 400 yards and upwards have generally been used, on those sides of a fortress only, which are considered the least liable to an assault, as for instance on the sea line of maritime fortresses; or on the bank of some large unfordable river. When fortresses are built with fronts of unequal lengths, they are said to be irregular. The nature of such works shall be more fully explained in a future chapter.

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* In measuring the extent of a town or city for the above purpose, it will of course be understood, that the outline chosen, which is to correspond with the exterior sides of the fortified polygon, must be traced at a sufficient distance beyond all the streets, buildings, &c. which it may be proposed to preserve.

Before we conclude this part of our subject, it may be proper to observe, that the length of a flank as measured on the out of any work, does not give a just criterion for calculating the exact number of flanking guns, that may be mounted thereon.

To explain this by a figure, draw a work resembling a small bastion with part of a curtain on each side of it.

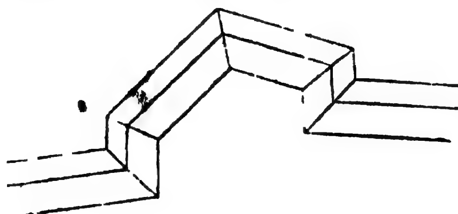


This figure may represent either the scarp line of a demireveted work of respectable height, or the foot of the exterior slope of the scarp of a field work. Let us suppose that the flanks are only 6 yards or 18 feet in length.

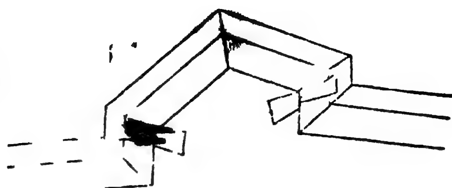
Then, as 18 feet is quite sufficient for a one-gun battery, it might at first sight be considered practicable to place one gun in each flank, in such a position as to be able to flank the adjoining curtains with proper effect. This however will not be the case, as will appear, when we proceed to complete the plan of our supposed work.

In rear of the various lines of your present figure, and parallel to them, at the distance of about 4 yards, draw a second set of lines, to represent the exterior crest of the parapet.

At the distance of 6 yards more, also set off towards the rear, draw a third set of parallel lines, in order to show the interior crest of the parapet; and complete your plan by inserting the necessary ridges and furrows.



This being done, draw a one-gun battery in each flank.



It now appears evident, that although one gun may be placed in each flank, it is quite impossible, on account of their oblique position, that either of these should act as flanking guns to protect the adjoining curtains. Consequently, in calculating the quantity of proper flanking defences, to be gained from any flank, a certain deduction must in all cases be made, on account of the space that is lost by reason of the exterior slope, and thickness of the parapet.*

* If the angle of the shoulder were a right angle, the space lost would be exactly equal to the base of the exterior slope and thickness of the parapet added together: but if the above angle is obtuse, which is almost always the case, then the space lost will be so much the less, in proportion to the magnitude of the angle.

END OF VOLUME II.

ERRATUM.

Page 240, Article 96, last line of the text. *For* ramps *read* barbets.

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